MITSUBISHI ELECTRIC

Mitsubishi Industrial Robot

CR750/CR751 series controller

MELFA-3D Vision Instruction Manual

4F-3DVS2-PKG1/4F-3DVS2-PKG2

MELFA

BFP-A3403-B

⚠ Safety Precautions

Always read the following precautions and separate "Safety Manual" carefully before using robots, and take appropriate action when required.

⚠ Caution	Teaching work should only be performed by those individuals who have undergone special training. (The same applies to maintenance work with the robot power ON.) → Conduct safety education.
⚠ Caution	Prepare work regulations indicating robot operation methods and procedures, and measures to be taken when errors occur or when rebooting robots, and observe these rules at all times. (The same applies to maintenance work with the robot power ON.) → Prepare work regulations.
⚠ Warning	Only perform teaching work after first equipping the controller with a device capable of stopping operation immediately. (The same applies to maintenance work with the robot power ON.) → Equip with an EMERGENCY STOP button.
⚠ Caution	Notify others when teaching work is being performed by affixing a sign to the START switch, etc. (The same applies to maintenance work with the robot power ON.) → Indicate that teaching work is being performed.
⚠ Warning	Install fences or enclosures around robots to prevent contact between robots and workers during operation. → Install safety fences.
⚠ Caution	Stipulate a specific signaling method to be used among related workers when starting operation. → Operation start signal
⚠ Caution	As a rule, maintenance work should be performed only after turning OFF the power, and other workers should be notified that maintenance is being performed by affixing a sign to the START switch, etc. → Indicate that maintenance work is being performed.
⚠ Caution	Before starting operation, conduct an inspection of robots, EMERGENCY STOP buttons, and any other related devices to ensure that there are no abnormalities. → Inspection before starting operation

The following precautions are taken from the separate "Safety Manual".

Refer to the "Safety Manual" for further details.

⚠ **Caution** Use robots in an environment stipulated in the specifications.
Failure to observe this may result in decreased reliability or breakdown.
(Temperature, humidity, atmosphere, noise environment, etc.)

⚠ **Caution** Only transport robots in the manner stipulated.
Failure to observe this may result in bodily injury or breakdown if the robot is dropped.

⚠ **Caution** Install and use the robot on a secure and stable platform.
Positional displacement or vibrations may occur if the robot is unstable.

⚠ **Caution** Ensure that cables are kept as far apart from noise sources as possible.
Positional displacement or malfunction may occur if in close contact with one another.

⚠ **Caution** Do not apply too much force to connectors, or bend cables too much.
Failure to observe this may result in contact defects or wire damage.

⚠ **Caution** Ensure that the weight of the workpiece, including the hand, does not exceed the rated load or allowable torque.
Failure to observe this may result in alarms or breakdown.

⚠ **Warning** Attach hands and tools, and grip workpieces securely.
Failure to observe this may result in bodily injury or property damage if objects are sent flying or released during operation.

⚠ **Warning** Ground the robot and controller properly.
Failure to observe this may result in malfunction due to noise, or even electric shock.

⚠ **Caution** Always indicate the robot operating status during movement.
If there is no indication, operators may approach the robot, potentially leading to incorrect operation.

⚠ **Warning** If performing teaching work inside the robot movement range, always ensure complete control over the robot beforehand. Failure to observe this may result in bodily injury or property damage if able to start the robot with external commands.

⚠ **Caution** Jog the robot with the speed set as low as possible, and never take your eyes off the robot. Failure to observe this may result in collision with workpieces or surrounding equipment.

⚠ **Caution** Always check robot movement in step operation before commencing auto operation following program editing. Failure to observe this may result in collision with surrounding equipment due to programming mistakes, etc.

⚠ **Caution** If attempting to open the safety fence door during auto operation, ensure that the door is locked, or that the robot stops automatically. Failure to observe this may result in bodily injury.

⚠ Caution Do not perform unauthorized modifications or use maintenance parts other than those stipulated. Failure to observe this may result in breakdown or malfunction.

⚠ Warning If moving the robot arm by hand from outside the enclosure, never insert hands or fingers in openings. Depending on the robot posture, hands or fingers may become jammed.

⚠ Caution Do not stop the robot or engage the emergency stop by turning OFF the robot controller main power.
Robot accuracy may be adversely affected if the robot controller main power is turned OFF during auto operation. Furthermore, the robot arm may collide with surrounding equipment if it falls or moves under its own inertia.

⚠ Caution When rewriting internal robot controller information such as programs or parameters, do not turn OFF the robot controller main power.
If the robot controller main power is turned OFF while rewriting programs or parameters during auto operation, the internal robot controller information may be destroyed.

⚠ Caution Attach the cap to the SSCNET III connector after disconnecting the SSCNET III cable. If the cap is not attached, dirt or dust may adhere to the connector pins, resulting in deterioration connector properties, leading to malfunction.

⚠ Caution Do not look directly at light emitted from the tip of SSCNET III connectors or SSCNET III cables. Eye discomfort may be felt if exposed to the light. (SSCNET III employs a Class 1 or equivalent light source as specified in JISC6802 and IEC60825-1.)

⚠ Warning Do not look directly at light emitted from the projector window of the camera head. Failure to observe this may cause eye impairment. Strict observance is required.

⚠ Caution The camera head of 3D Vision has a precision structure. Handle with due care and avoid excessive impact.

■ Revision History

Print Date	Instruction Manual No.	Revision Details
2015-July-14	BFP-A3403-A	• First edition
2016-July-15	BFP-A3403-B	Ver.1.2 • Added model-less dedicated version "4F-3DVS2-PKG2". • Added the Ready signal function. • Added the adjust function for projector/camera. • Added the camera parameter. • Added the distortion correction. • Added the Z accuracy validation function for XY calibration. • Changed the measurement parameter. • Added the model-less parameter. • Improved the setting screen for model-less recognition. • Added the model matching parameter. • Extended the upper limit of the recognized number of pieces. • Added Q&A.

■ Introduction

Thank you for considering the use of this option for Mitsubishi Electric industrial robot. The "MELFA-3D Vision" is a compact 3D vision sensor for robots, and employs a camera head capable of acquiring distance information to measure and recognize parts loaded in bulk, enabling them to be gripped by the robot. It is ideal for such tasks as part feeder replacement, and the simplification of positioning units.

Always read over this manual to gain a sufficient understanding of its content before using the “MELFA-3D Vision”.

This instruction manual describes the system configuration and product specifications of "MELFA-3D Vision". Refer to the separate “Instruction Manual/Detailed Explanations of Functions and Operations” for information on basic operation.

■ Notation used in this manual

⚠ **Danger**	Incorrect handling may result in imminent danger, leading to death or serious injury.
⚠ **Warning**	Incorrect handling may lead to death or serious injury.
⚠ **Caution**	Incorrect handling may result in property damage, or danger leading to impairment of the user.

CONTENTS

1. USING THIS PRODUCT

1.1. Content of This Instruction Manual

In this manual, how to use MELFA-3D Vision is described in the following configuration. For details on standard robot controller functions and operations, refer to the "Instruction Manual" provided with the robot controller.

Table 1-1: Instruction manual content

Chapter	Title	Description
1	Using This Product	Describes the construction of this manual.
2	Work Flow	Describes the work required to construct systems using MELFA-3D Vision. Please carry out the work as described.
3	MELFA-3D Vision System Specifications	Describes the MELFA-3D Vision system specifications.
4	Check Before Use	Describes the product configuration and equipment to be prepared by the user. Check whether all the required products have been prepared, and check the versions of the robot controller and RT Toolbox2.
5	Camera Head Attachment	Describes the camera head attachment method. Read all the installation precautions and start the attachment work.
6	Device Connection and Wiring	Describes how to connect the devices being used.
7	Using MELFA-3D Vision	Describes how to use MELFA-3D Vision.
8	Language Specifications	Describes detailed specifications of MELFA-BASIC language relating to MELFA-3D Vision.
9	Parameter Specifications	Describes detailed specifications for parameters relating to MELFA-3D Vision.
10	Troubleshooting	Describes the details of errors and countermeasures for MELFA-3D Vision.

1.2. Glossary

The following terms are used in this manual.

Table 1-2: Description of terms

Term	Description
Camera head	A unit consisting of the projector, camera, and mounting base
Control unit	A unit to receive commands from the robot controller. It sends imaging commands to the camera head, calculates range images from captured pattern images, performs recognition from range images, and notifies the robot controller of the recognition results.
Hand eye	A method used to perform measurement and recognition with the camera head attached to the robot hand
Fixed camera	A method used to perform measurement and recognition with the camera head attached on the device frame, etc. The camera head cannot be moved as in the hand eye method.
Workpiece distance	A distance range from the lens attachment flange surface to the point of measurement (See Note 2 in 3.5 Camera Head Specifications.)
Calibration	An operation to calculate parameters in the optical model and the matrix to correct positions for the optical system and the robot
Job	An executable unit of work such as measurement or recognition executed by the control unit
Measurement	A process to calculate distance within the visual field of the camera in pixel units according to the principle of triangulation. It uses pattern images irradiated from the projector, and output range images.
Range image	An image that expresses distance information from the camera head to the workpiece in 2D image shading. The closer the camera head, the brighter the image appears.
Recognition	A process to cut out the workpiece from the range image obtained by measurement, and calculate the robot coordinates for the workpiece
Model-less recognition	A recognition method that facilitates the gripping of workpieces by registering the shape of hand claws and suction pads and recognizing gaps into which claws can be inserted and pad suction locations. No need to register workpiece shapes. Depending on the circumstances, a 2D vision sensor may be required.
Segment	Refers to a small area of any size in the captured image, it is one of the processing units in the image processing. It is divided into segments subjected to various processes to the captured image or the distance image.
Model matching recognition	A recognition method that facilitates the gripping of workpieces by registering workpiece shapes in 3D-CAD models and recognizing workpieces that match the 3D-CAD models

2. WORK FLOW
2.1. Flowchart

1. MELFA-3D Vision system specifications: See "Chapter 3" in this manual. Check the MELFA-3D Vision system configuration and function specifications, and then carry out the following.

↓

2. Product check: See "Chapter 4" in this manual. Check the purchased product, and prepare the required items.

↓

3. Camera head attachment method: See "Chapter 5" in this manual. Attach the camera head.

↓

4. Device connection and wiring: See "Chapter 6" in this manual. Connect the control unit and the camera, and perform initial setting of the parameters.

↓

5. Using MELFA-3D Vision: See "Chapter 7" in this manual. Describes how to use MELFA-3D Vision. Use MELFA-3D Vision while referring to the detailed descriptions.

3. MELFA-3D VISION SYSTEM SPECIFICATIONS

3.1. What is MELFA-3D Vision?

MELFA-3D Vision is a compact 3D vision sensor for robot use, and employs a camera head capable of acquiring distance information to measure and recognize parts loaded in bulk, enabling them to be gripped by the robot.
It is ideal for such tasks as part feeder replacement, and the simplification of positioning units.

<Main features>

(1) Equipped with a compact, lightweight camera head, and compatible with both the hand eye and fixed camera methods.
(2) High-speed, high-accuracy measurement
(3) Various workpieces loaded in bulk can be taken out simply by registering the hand tip shape. (Model-less recognition)
(4) Gripping of bulk-loaded workpieces is possible in consideration of their posture by registering the workpiece shape. (Model matching recognition)
(5) Sensor settings and operation checks can be easily performed using a computer.
No need to keep connection with the computer during operation.

◇◆◇Model matching recognition◇◆◇
Please contact Mitsubishi Electric for using the model matching recognition.

3.2. Measurement Principal

This product measures distance using a camera head comprised of a projector and a camera. The measurement principal is briefly described below.

Fig. 3-1 Camera head

Patterns such as those shown in Fig. 3-2 are irradiated from the projector, and these are captured by the camera. By processing these images, the pattern irradiation range can be split into several hundred divisions, each of which can be identified by assigning a number.

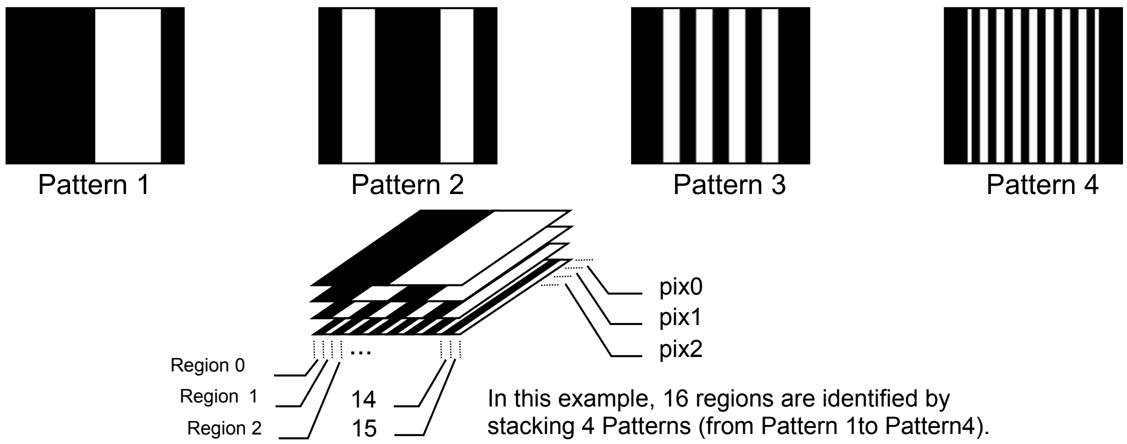


Fig. 3-2 Pattern irradiation example

The projector optical axis at this time is tilted toward the camera head as shown in Fig. 3-3, and therefore the closer the workpiece gets to the projector, the divided areas move toward the projector. Consequently, distance can be calculated based on how much the divided area on the workpiece has moved toward the projector side relative to the position on the measurement stand. By performing this procedure for all camera pixels, range images can be calculated.

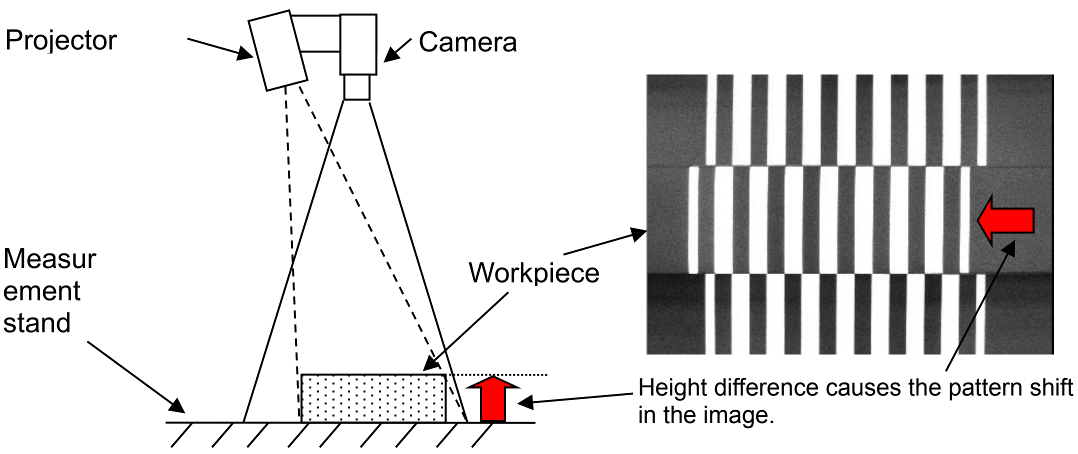


Fig. 3-3 Relationship between projector and camera

3.3. System Configuration Example

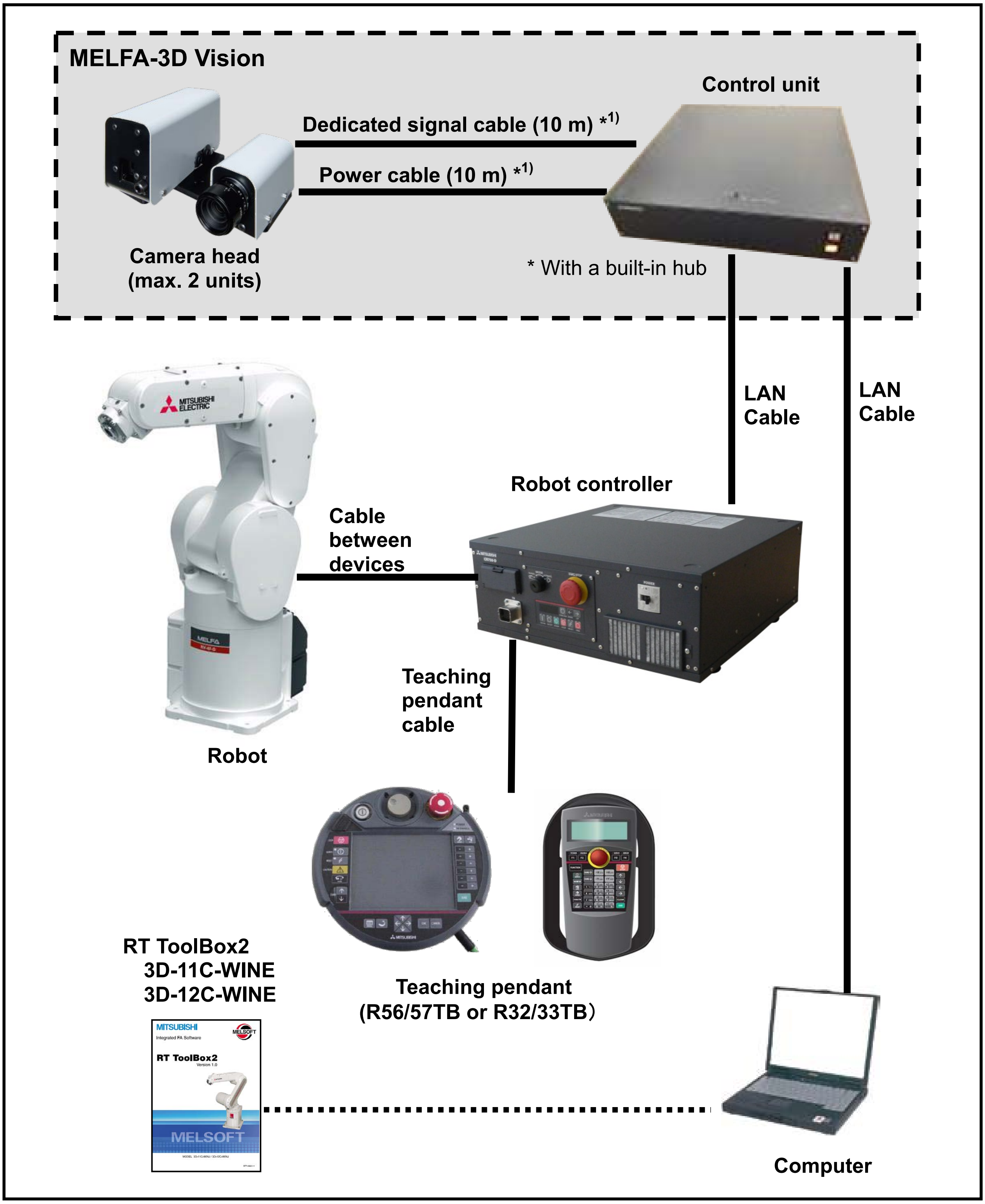


Fig. 3-4 MELFA-3D Vision system configuration drawing

*1) When you attach a shield cover to reduce the electrical noise, please cover these cables from the end point near by the control unit.

3.4. MELFA-3D Vision Specifications

The MELFA-3D Vision specifications are as follows.

Table 3-1: MELFA-3D Vision specifications

Item				Function details
Applicable robot				Vertical, multiple-joint type RV-F series [Note 1]
Robot programming language				MELFA-BASIC V
Robot controller	MELFA-3D Vision dedicated commands			Dedicated commands used to notify the control unit of calibration and job execution commands, and to acquire recognition results
Control unit	Measurement [Note 2]			Imaging commands are sent to the camera head, and range images are calculated from captured pattern images.
		Measurement time		About 1.3 to 1.8 s
	Recognition	Model-less recognition		A recognition method that facilitates the gripping of workpieces by registering the shape of hand claws and suction pads and recognizing gaps into which claws can be inserted and pad suction locations
			Recognition result output information	Posture output mode "0": Workpiece position of camera coordinates (XYZC) Posture output mode "1 to 4": Workpiece position of robot coordinates (XYZABC)
			Recognition time	About 1.2 to 2 s [Note 3]
		Model matching recognition [Note 6]		A recognition method that facilitates the gripping of workpieces by registering workpiece shapes in 3D-CAD models and recognizing workpieces that match the 3D-CAD models
			Recognition result output information	Workpiece position in robot coordinates (XYZABC)
			Recognition time	About 3 to 5 s [Note 3]
RT ToolBox2	Connection settings			The function used to specify camera and robot communication settings
	Calibration			The function used to create and edit calibration data
	Measurement/recognition			The function used to create and edit jobs for measurement and recognition
	Monitoring			The function used to monitor measurement and recognition results
	Maintenance			The function used to back up and restore data inside the control unit
	Software update			The function used to update the control unit software

Note 1: The RV-F series is not compatible with internal wiring specifications.

Note 2: Shielding may be required against the influence of ambient environmental light. Projector light tends to weaken as the workpiece distance increases, enhancing the influence of ambient environmental light.

Note 3: This is the standard time from the start of recognition until output. The standard time may be exceeded depending on conditions such as the ambient environment, workpiece, and processing parameters.

Note 4: Measurement may not be possible or may be difficult for the following workpieces.

- Transparent objects, specular objects

Furthermore, measurement and recognition of the following workpieces may be difficult.

- High-gloss objects, black-colored objects, dark-colored objects, objects with complex surface shape

Make a request for testing samples, if it is difficult to judge whether measurement is possible or not.

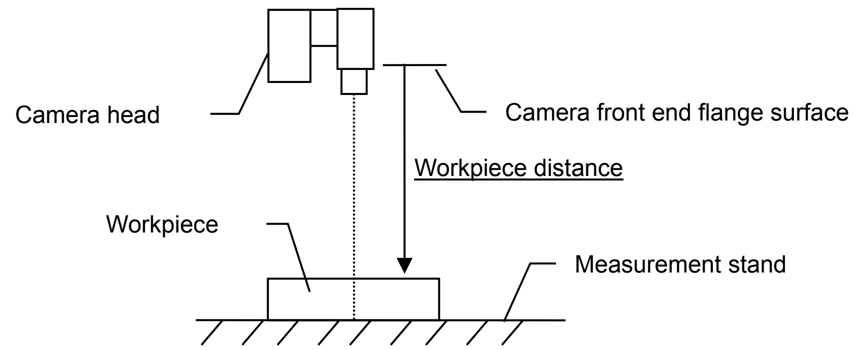
Note 5: For a picking operation of the model-less recognition, a 2D vision sensor may be required.

Note 6: Model recognition matching can only be used for "4F-3DVS2-PKG1".

3.5. Camera Head Specifications

Table 3-2: Camera head specifications

Item			Unit	Specification	Remarks
Model name			-	2F-3DVS2-HEAD	
Measurement method			-	Triangulation method (pattern irradiation type)	
Active light source			-	LED projector	
Lens	Mounting method		-	C mount	
	Focal length		mm	12.5 (Accessories), 9.0 (Option) [Note9]	
No. of measurement points			Points	About 300,000 to 600,000 [Note 1]	
Working distance [Note 2] [Note 3]	Standard Field of View (FOV)	Mounting base (small)	mm	300 to 500	
		Mounting base (large)		(1) 500 to 750 [Note 4] (2) 750 to 1000 [Note 5]	
Measurement view [Note 3] (horizontal x vertical x height)		Mounting base (small)	mm	100 x 80 to 165 x 130, about 70 mm	Equivalent measurement viewing angle: About 15 to 20 [Note 1]
		Mounting base (large)		(1) 165 x 130 to 245 x 200 [Note 4], about 100 mm (2) 245 x 200 to 340 x 265 [Note 5], about 150 mm	
Working distance [Note 2] [Note 3]	Extended Field of View (FOV)	Mounting base (small)	mm	300 to 500	
		Mounting base (large)		(1) 500 to 750 [Note 4] (2) 750 to 1000 [Note 5]	
Measurement view [Note 3] (horizontal x vertical x height)		Mounting base (small)	mm	140 x 90 to 240 x 160, about 70 mm	Equivalent measurement viewing angle: About 20 to 28 [Note 1]
		Mounting base (large)		(1) 240 x 160 to 375 x 250 [Note 4], about 100 mm (2) 375 x 250 to 525 x 350 [Note 5], about 150 mm	
Measurement error (Z-direction) [Note 8]			mm	About 0.3 ~ [Note 1]	
External dimensions	Mounting base (small)		mm	146 (W) x 87 (H) x 138 (D) [Note 9]	Max. +50mm (W) [Note 7] at Extended FOV
	Mounting base (large)		mm	396 (W) x 87 (H) x 138 (D) [Note 9]	
Weight			kg	About 0.9	
Cable			-	For bending (power cable, dedicated communication cable)	10 m
Construction			-	Open type	IP20 [Note 10]
Operating temperature range			°C	5 to 40	
Relative humidity			%RH	45 to 85	No dew condensation
Surrounding atmosphere			-	No corrosive gas, dust, or oil mist	
Paint color			-	Light gray (0.6B7.6/0.2 approximate color) Black (N1.5 approximate color)	



Note 1: This will differ based on the extent of projector irradiation range and camera field of view overlapping due to the workpiece distance.
Note 2: This is the distance range from the camera lens attachment flange surface to the point of measurement.
Note 3: Refer to "3.7.3 Measurement view and workpiece distance" for details on the relationship between the workpiece distance and measurement view.
Note 4: If camera attached to mounting base (large) (i) (see Fig. 3-8 Mounting base (large))
Note 5: If camera attached to mounting base (large) (ii) (see Fig. 3-8 Mounting base (large))
Note 6: When standard lens (f = 12.5 mm) attached
Note 7: When optional lens (f=9mm) and camera mounting base for the horizontal installation are attached
Note 8: This is the measurement value variation range, and differs from the absolute measurement accuracy. Furthermore, this is a reference value measured under conditions specified by Mitsubishi Electric. This value will change based on the workpiece distance and sensor parameters, and the workpiece shape and surface condition.
Note 9: Protrusions are not included.
Note 10: General environmental conditions apply to this camera head. (See "3.5.1 Protection specifications and working environment".)

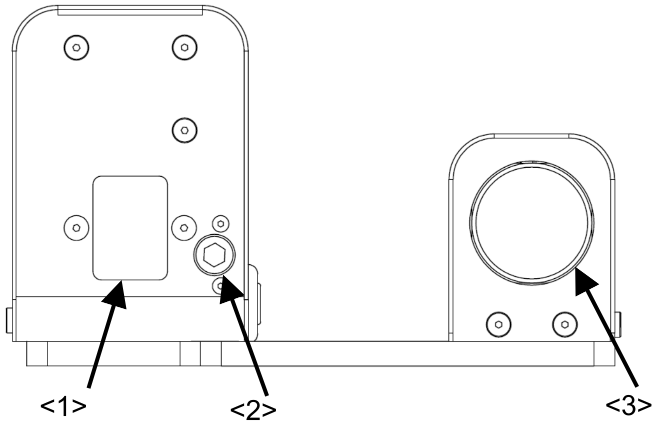
3.5.1. Protection specifications and working environment

The camera head employs a protection method conforming to IEC standard IP20 (open type).
Please note that the IP performance of IEC standard specifies the protection level against solid bodies and water, not against oil. Take care not to directly expose the camera head to oil and so on.

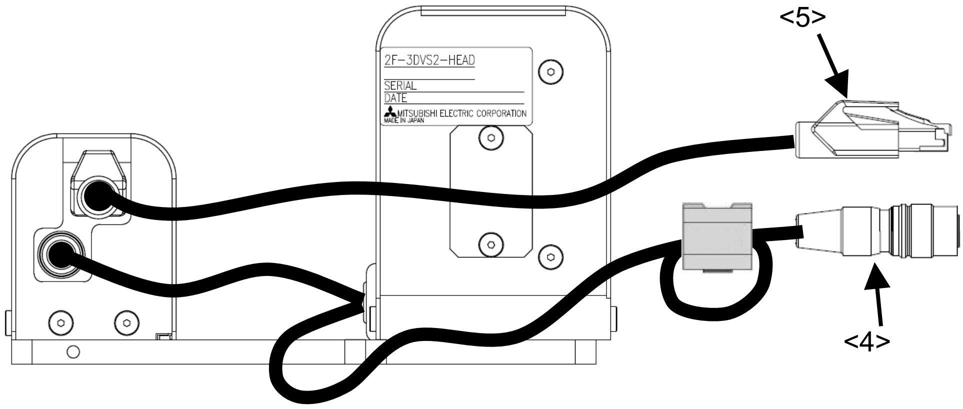
[Reference]
• IEC standard IP20
This refers to a protective structure that prevents an iron ball of diameter $12_{0}^{+0.05}$ mm, which is being pressed with a force of 3.1 kg ±10%, from going through the opening of the outer casing of the tested equipment.

3.5.2. Name of each part

<Camera head front view>



<Camera head rear view>



<Camera head underside view>

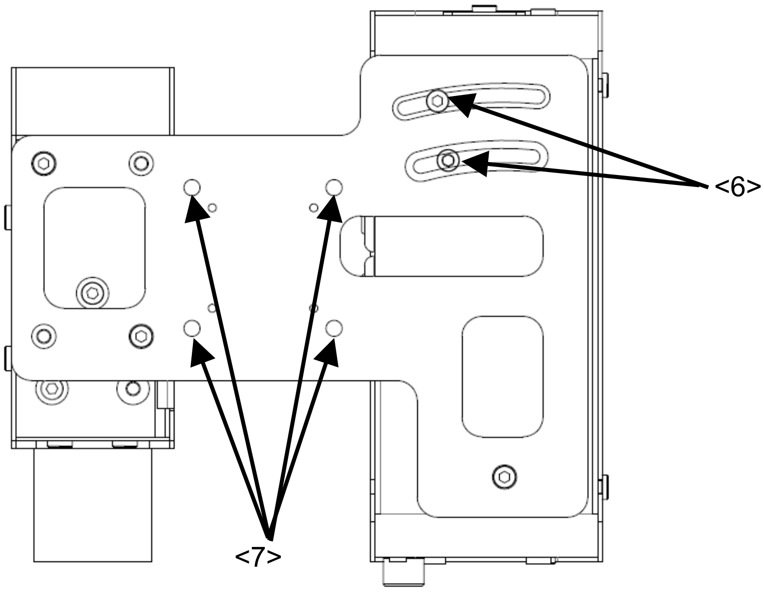


Fig. 3-5 Name of each camera head part

<1> Projector window: The projector irradiates light from here.
<2> Projector focus adjustment knob: Focus of the projector can be adjusted by turning the knob.
<3> Camera lens: The camera head is equipped with a standard lens.
<4> Power connector: This connects to the control unit <c> DCOUT connector.
<5> Dedicated communication connector: This connects to the control unit <d> LAN connector.
<6> Projector angle adjustment screws: The angle is adjusted by tightening and then securing the projector at the desired angle.
<7> Camera head attachment screw holes: These are the screw holes used to attach the camera head.

3.5.3. External dimensions

(1) Camera head

The camera head external drawing is shown below.

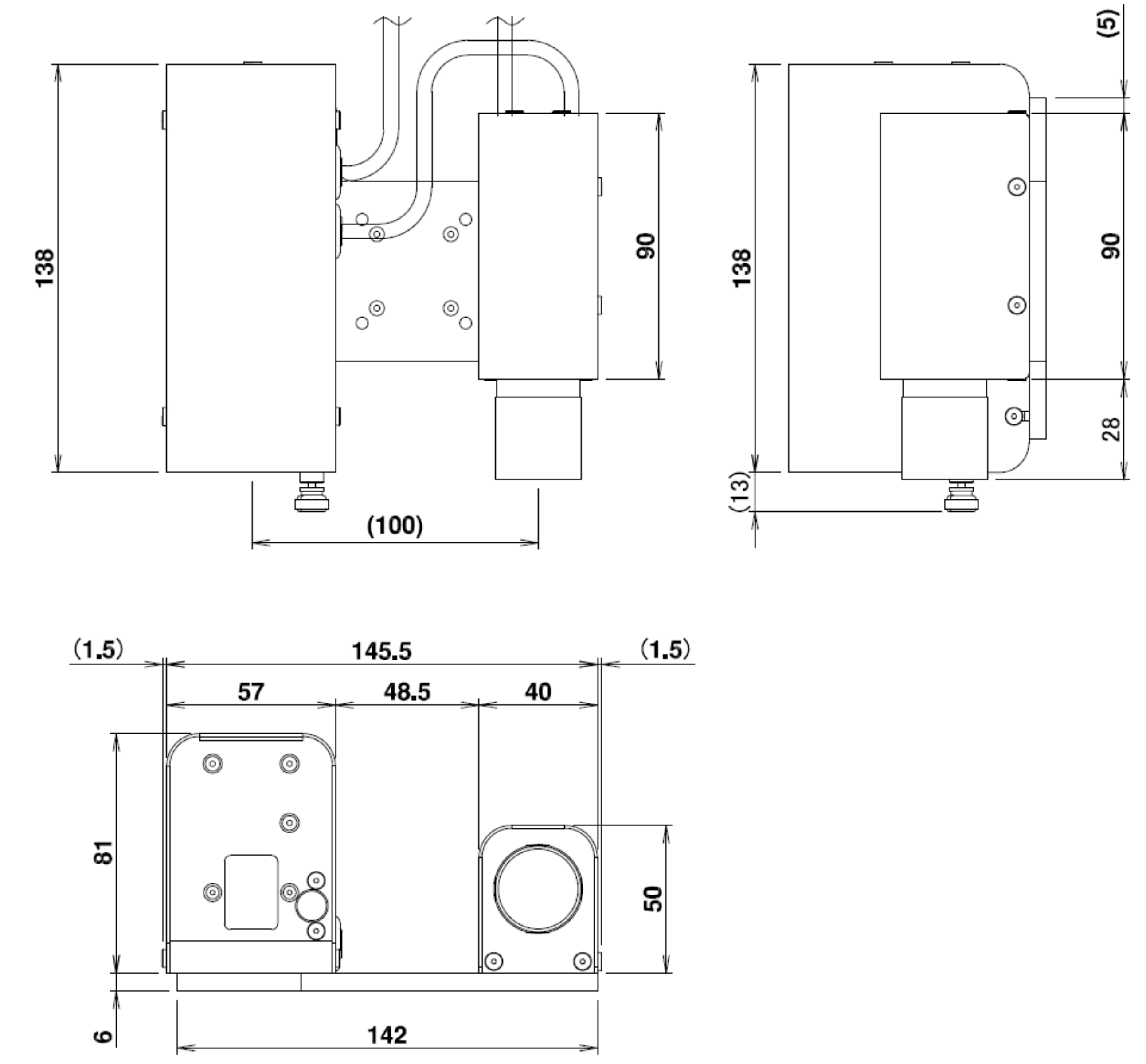


Fig. 3-6 Camera head external drawing (for mounting base (small))

(2) Mounting base
The mounting base external drawing is shown below.

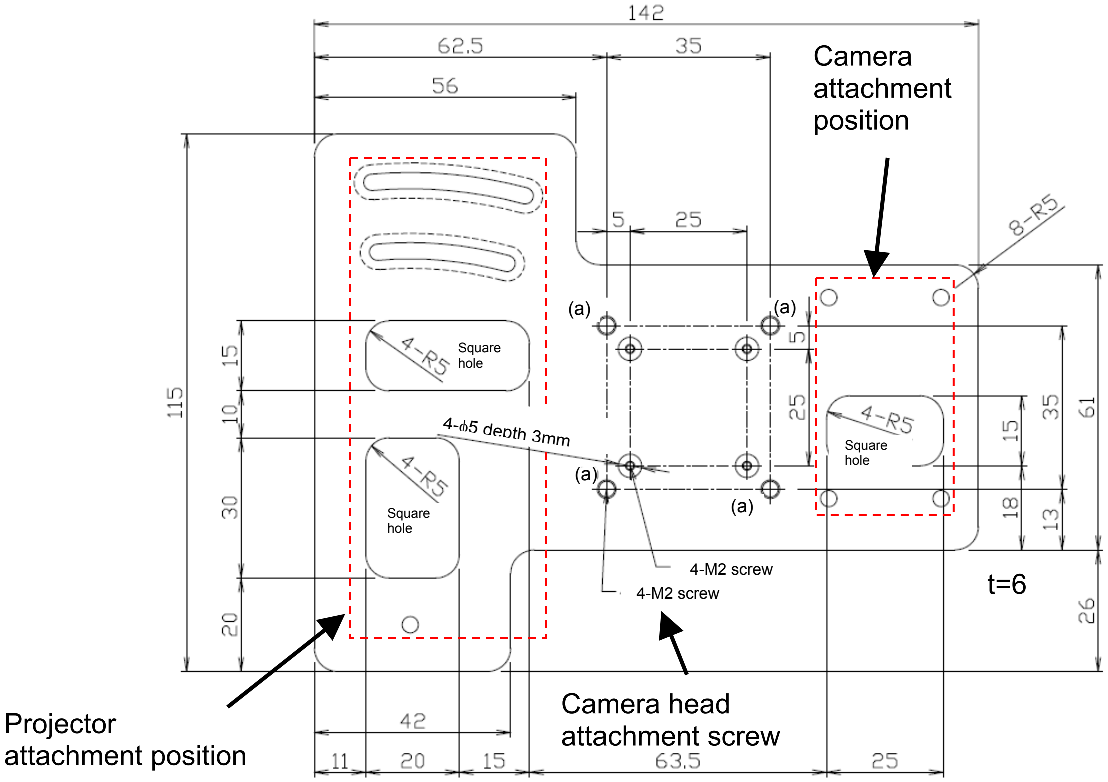


Fig. 3-7 Mounting base (small) (2F-3DVS2-BASE-S) Note 1

Note 1: Factory attached

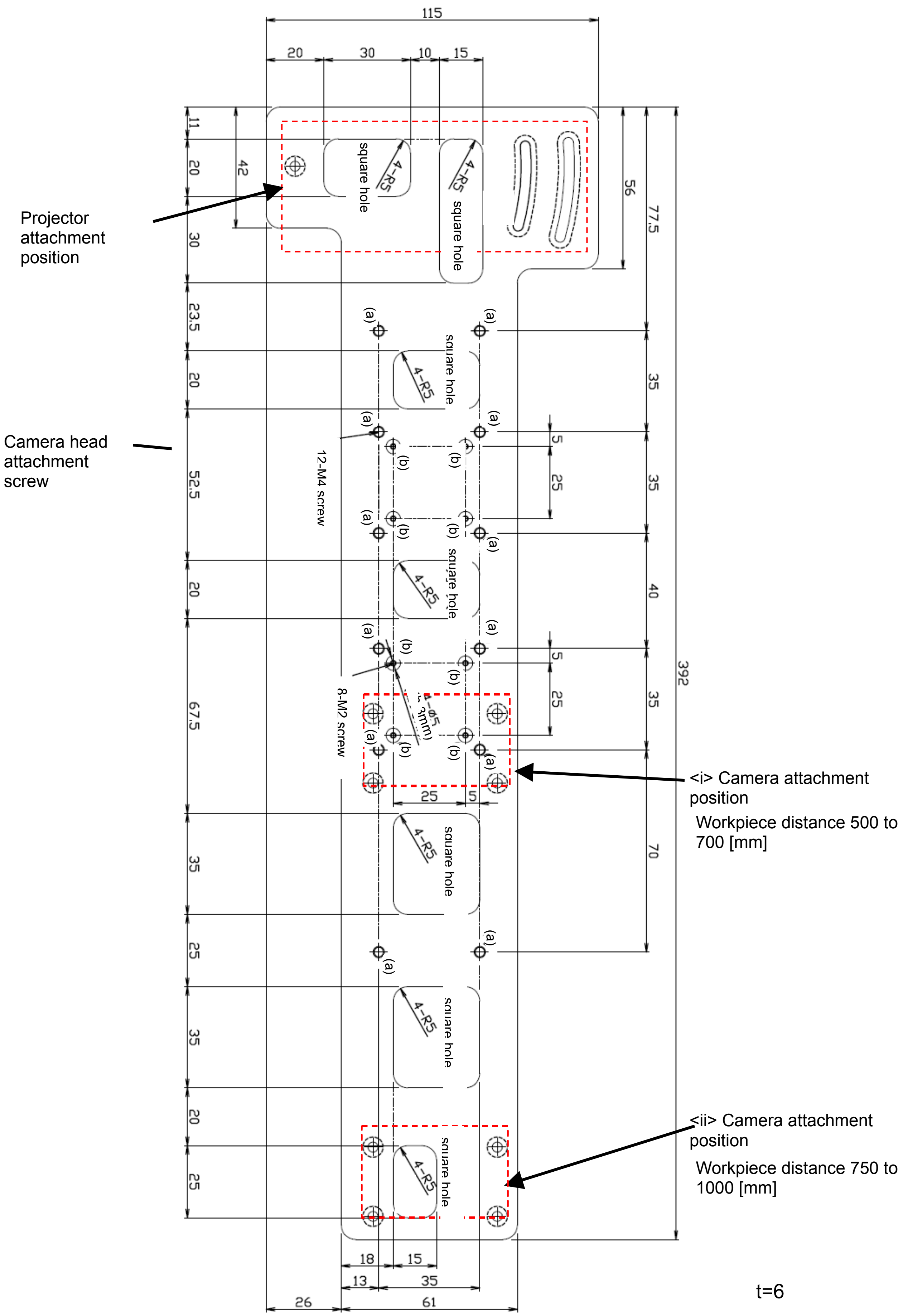


Fig. 3-8 Mounting base (large) (2F-3DVS2-BASE-L)

3.5.4. Camera coordinate system

The camera coordinate system is defined as follows.

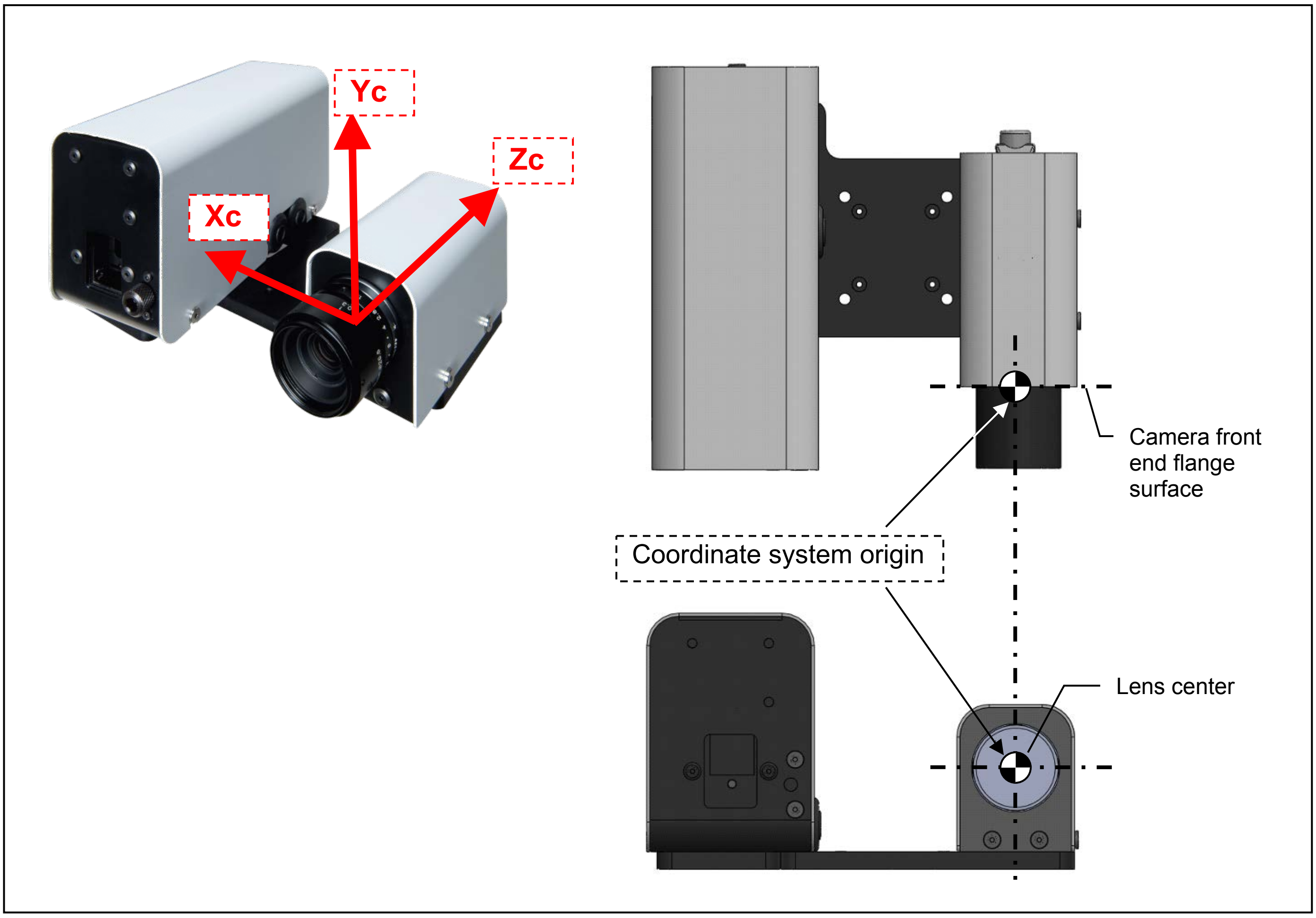


Fig. 3-9 Camera coordinate system

3.6. Control Unit Specifications

Table 3-3: Control unit specifications

Item		Unit	Specification	Remarks
Model name		-	2F-3DVS2-UNIT	
Number of connected units		-	Camera head: Max. 2 units [Note 1] Robot controller: Max. 4 units [Note 2]	
Interface	Gigabit Ethernet	Port	7 [Note 3]	
External power supply	Input voltage range	V	Single-phase 180 to 253 VAC	
	Power supply capacity	kVA	0.2	Not including inrush current
	Power supply frequency	Hz	50/60±3	
	Permissible momentary stop time	ms	20 or lower	
External dimensions		mm	430 (W) x 370 (H) x 98 (D)	
Weight		kg	About 12.2	
Cable		-	With a control-unit-side connector, and a round terminal on the other end (power cable)	1 m Round terminal: JST, R1.25-3.5
Construction		-	Independent installation, open type	IP20 [Note 4]
Operating temperature range		°C	5 to 40	
Relative humidity		%RH	45 to 85	No dew condensation
Surrounding atmosphere		-	No corrosive gas, dust, or oil mist	
Paint color		-	Dark gray (3.5PB3.2/0.8 approximate color)	

Note 1: It is not possible to use two camera heads to simultaneously perform measurement and recognition.
Note 2: Jobs cannot be executed simultaneously from multiple robot controllers.
Note 3: Two ports are for camera heads, four ports are for robot controllers, and one port is for a computer. The connections do not have to be in particular order.
Note 4: General environmental conditions apply to this control unit. (See "3.6.1 Protection specifications and working environment".)

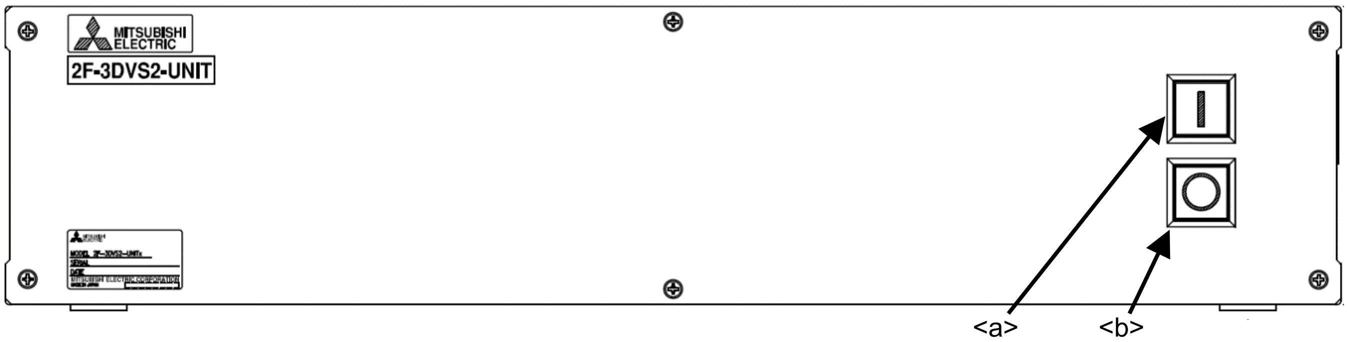
3.6.1. Protection specifications and working environment

The control unit employs a protection method conforming to IEC standard IP20 (open type).
Please note that the IP performance of IEC standard specifies the protection level against solid bodies and water, not against oil.

[Reference]
• IEC standard IP20
This refers to a protective structure that prevents an iron ball of diameter $12_{0}^{+0.05}$ mm, which is being pressed with a force of 3.1 kg ±10%, from going through the opening of the outer casing of the tested equipment.

3.6.2. Name of each part

<Control unit front view>



<Control unit rear view>

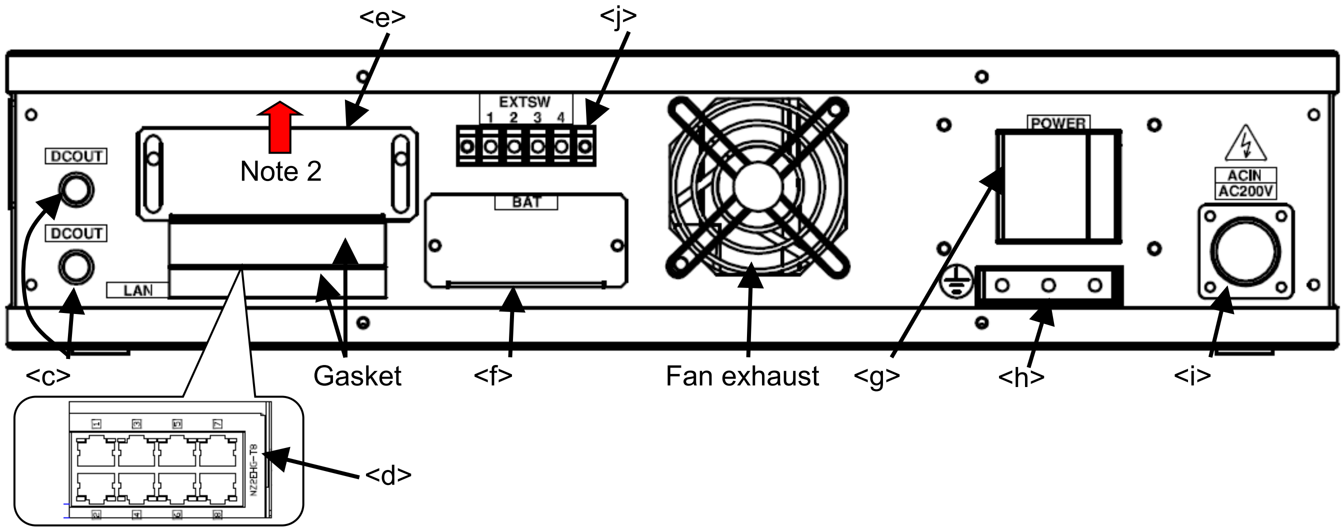


Fig. 3-10 Name of each control unit part

<a> Power ON switch: .... This switch turns the control power ON. The switch lights up in green while the power is ON. [Note 1]
<b> Power OFF switch:................. This switch turns the control power OFF. The switch lights up in red while the power is OFF. [Note 1]
<c> DCOUT connector:................. Connects to the camera head power supply connector. The connection destinations for each camera head are in no particular order.
<d> LAN connector: .... Connects to the camera head, robot controller, and computer LAN connectors. [Note 2]
<e> LAN cable securing plate: .... By loosening the screws and sliding the plate, LAN cables are held with gasket and secured.
<f> Battery cover:........................... The battery is located inside the cover.
<g> Main power switch:.................. This is the main power ON/OFF switch.
<h> Ground terminals: .... These are for grounding connection.
<i> ACIN connector: .... AC power supply (single-phase, 200 VAC)
<j> Remote power supply ON/OFF switch terminal block: Terminal block used to turn the control power ON and OFF remotely. (See section 6.2.) [Note 3]

Note 1: The main power supply must be ON.
Note 2: There is a connector at the back that can be accessed by sliding <e> up.
Note 3: If the control unit is installed inside the system panel, this is used to turn the control power ON and OFF from outside the panel.

⚠ CAUTION

If connecting the control unit LAN to a commercial device (laptop computer, desktop computer, LAN hub, etc.), some devices may not be compatible with Mitsubishi Electric devices, and may be unsuitable for FA environments in terms of temperature and noise, etc. In such a case, carry out sufficient operation checks because separate measures such as EMI (Electro-Magnetic Interference) countermeasures or the addition of a ferrite core may be necessary.
Please note that Mitsubishi Electric cannot guarantee operation or perform maintenance for connection with commercial devices.

3.6.3. External and installation dimensions

3.6.3.1. External Dimensions

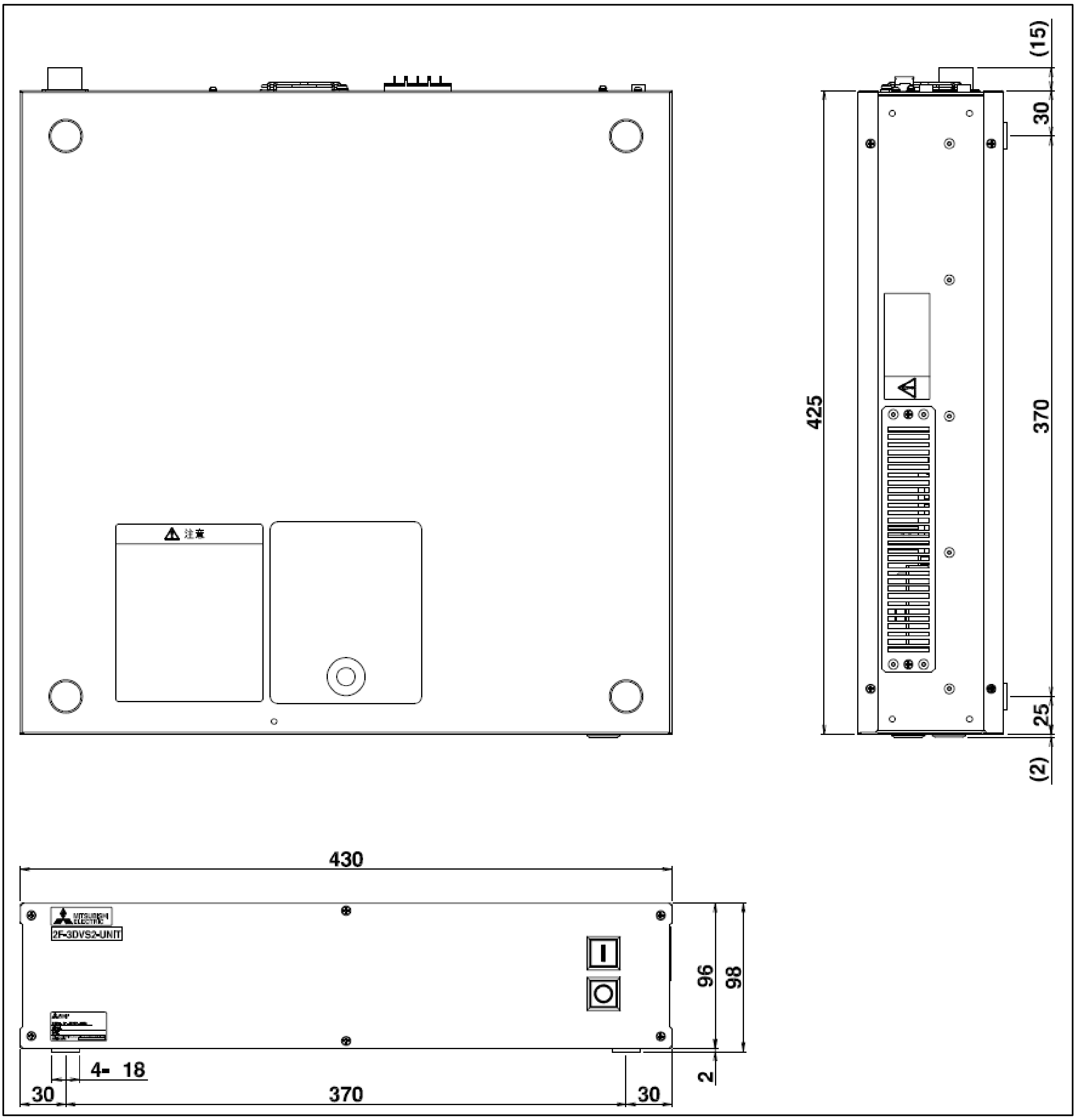


Fig. 3-11 Dimensional outline drawing of the control unit

3.6.3.2. Installation dimensions

<Control unit horizontal installation>

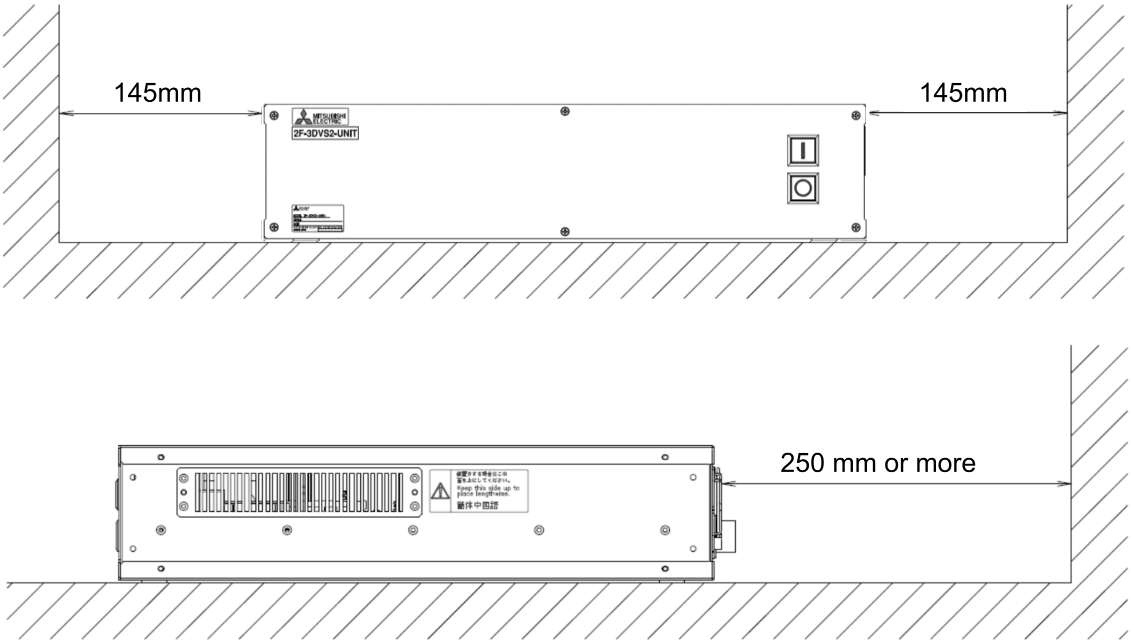


Fig. 3-12 Installation dimensional drawing in a horizontal state

<Control unit vertical installation>

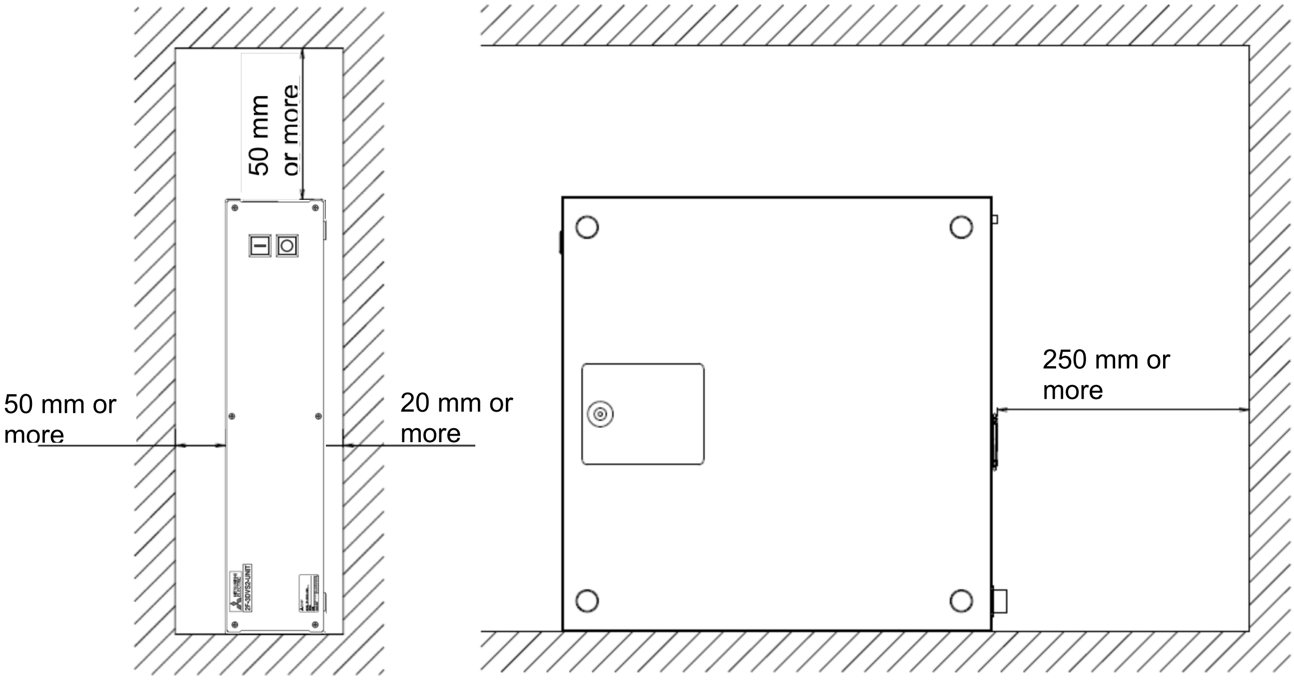


Fig. 3-13 Installation dimensional drawing in a vertical state

⚠ CAUTION

If the control unit is installed vertically, take measures to prevent it falling over such as securing it during installation. Fig. 3-14 shows a reference figure of the metal plate used to secure the vertically-installed control unit. Refer to this drawing if the control unit is installed vertically. Use M4 x 8 screws or shorter to secure the metal plate to the controller. (The amount of screw protrusion on the inside of the controller panel (side plate thickness: 1.2 mm) must be no greater than 6.8 mm.

⚠ CAUTION

If using the control unit inside a cabinet, etc., take sufficient heat dissipation and ventilation measures to keep the ambient temperature within the specification. Furthermore, do not install the control unit in a place exposed to direct sunlight or heat from lighting. Doing so could lead to a rise in the controller surface temperature, resulting in an error.

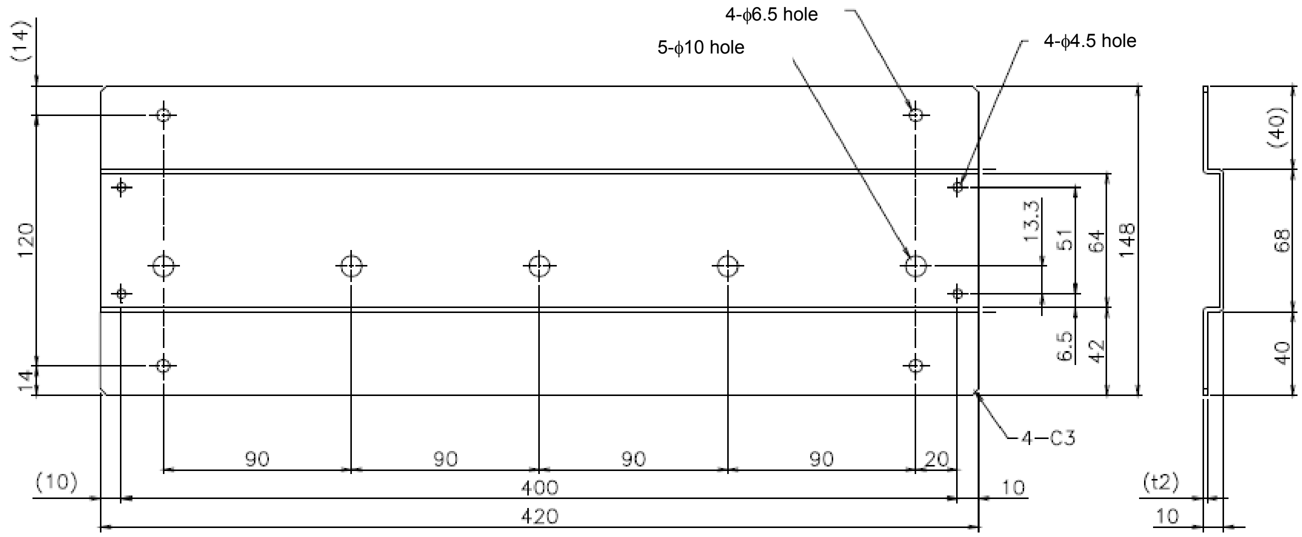


Fig. 3-14 Reference drawing of metal plate used to secure vertically-installed control unit

3.7. Restrictions

3.7.1. Restrictions applicable to measurement and recognition

(1) Measurement is not possible for workpieces with the following characteristics.
- Transparent objects
- Specular objects

(2) Measurement and recognition of workpieces with the following characteristics may be difficult. Furthermore, the greater the workpiece distance, more restrictions are placed on the conditions allowing measurement.
- High-gloss objects
- Black-colored objects
- Dark-colored objects
- Objects with complex surface shape

(3) Workpiece size (reference values)
Model-less: A short-side length of about 1/25 of the measurable area Note 1 and a long-side length of about 1/3 of the measurable area Note 1
Model matching: A short-side length of about 1/10 of the measurable area Note 1 and a long-side of about 1/3 of the measurable area Note 1

* The size depends on the conditions such as the workpiece distance, sensor parameters, workpiece shape, and surface condition. The above values are indicated for reference on the basis of Mitsubishi Electric test conditions.

Request sample testing if it is difficult to judge whether measurement is possible or not.

Note 1: See Fig. 7-39.

3.7.2. Unmeasurable area of parts supply box

Based on the measurement principle described in 3.2, there are areas where pattern irradiation is shielded by the wall of the parts supply box, meaning that there is a certain unmeasurable area. Consequently, there may be times when it is not possible to take out all workpieces from the parts supply box.

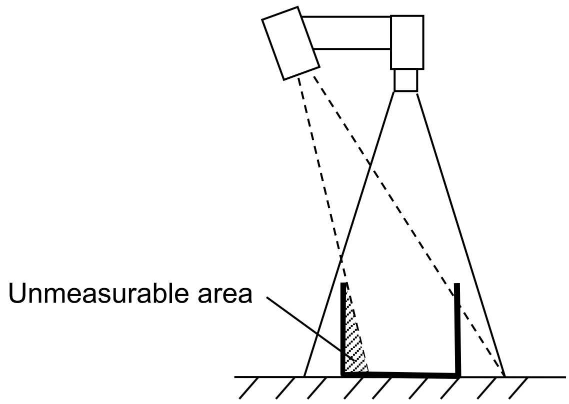


Fig. 3-15 Unmeasurable area of parts supply box

◇◆◇Unmeasurable area◇◆◇
- By bending the walls of the parts supply box as shown below, the unmeasurable area can be reduced.

- When using the hand eye, by rotating the measurement posture 90° or 180° around the camera optical axis and measuring, there are cases where locations that were previously not measureable can be available for measurement. However, it is necessary to rotate within the range in which the camera head does not interfere with the robot.

3.7.3. Measurement view and workpiece distance

As shown in Fig. 3-16, the projector irradiation range gets smaller as the workpiece gets closer, resulting in a smaller measurement view.

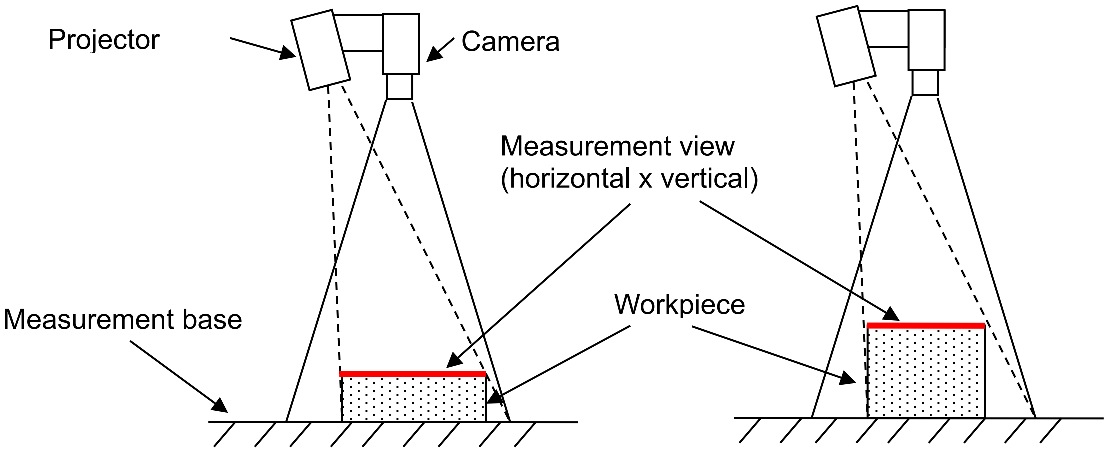


Fig. 3-16 Relationship between measurement view and workpiece distance

3.7.4. Picking with model-less recognition

Picking in consideration of the workpiece posture is not possible with model-less recognition. Consequently, a 2D vision sensor may be required for re-gripping of workpieces after they are taken out.
Furthermore, there may also be times when the hand claw interferes with the wall of the parts supply box for workpieces located in the corner of the box, preventing those workpieces from being taken out.

4. CHECK BEFORE USE

4.1. Product Check

The standard configuration for this product is as follows. Ensure that package contains the following items.
* If something is missing, please contact your sales office or the sales representative from which you purchased the product.

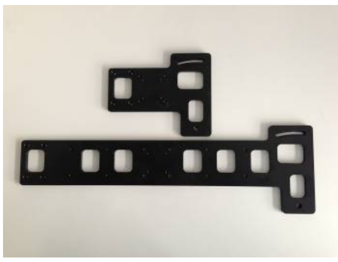
Table 4-1: MELFA-3D Vision product configuration list

No.	Parts name	Model name	Qty	Remarks
(1)	Camera head (with dedicated communication cable, power cable, and lens)	2F-3DVS2-HEAD	1	Lens: F = 12.5 mm
(2)	Mounting base Small (when shipped from factory) / large	2F-3DVS2-BASE	1 set	
		2F-3DVS2-BASE-S	1	Small (already attached to (1))
		2F-3DVS2-BASE-L	1	Large
(3)	Control unit (power cable provided)	2F-3DVS2-UNIT	1	
(4)	Calibration jig Z/XY/robot plate Raising block	2F-3DVS2-CALIB	1 set	
		2F-3DVS2-Z-S [Note 1] [Note 2]	1	30 (W) x 300 (L) (mm)
		2F-3DVS2-Z-M [Note 1] [Note 2]	2	55 (W) x 300 (L) (mm)
		2F-3DVS2-Z-L [Note 1] [Note 2]	2	80 (W) x 300 (L) (mm)
		2F-3DVS2-XY [Note 1] [Note 3]	1	40 x 40 (mm)
		2F-3DVS2-XYR-M [Note 4]	1	60 x 60 (mm)
		2F-3DVS2-XYR-L [Note4]	1	80 x 80 (mm)
		2F-3DVS2-STAND [Note 5]	6	35 x 30 x 20 (mm)
(5)	CD-ROM (instruction manual, sample program, etc.)	4F-3DVS2-CD	1	
(6)	Extended field of view option (Additional lens, Camera mounting base for the horizontal installation)	2F-3DVS2-OPT2	1	Optional
(7)	Additional camera head	4F-3DVS2-OPT1	1	Optional [(1)+(2)+(4)]

Note 1: The jig is different on each side. Use with the matte surface facing up.
Note 2: Z calibration plate
Note 3: XY calibration plate
Note 4: XY and robot calibration plate
Note 5: Raising block

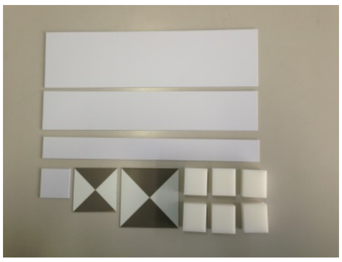
(1) Camera head

(2) Mounting base set
(The small one is attached to (1) when the product is shipped.)

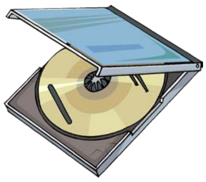


(3) Control unit

(4) Calibration jig



(5) CD-ROM



(6)Extended Field of view option

4.2. Items to be Prepared by Customer

To configure the system, prepare necessary equipment in addition to this product. The minimum requirements are shown in Table 4-2 List of items prepared by customer.

Table 4-2 List of items prepared by customer

No.	Parts name	Specification	Qty	Remarks
(1)	Computer	• CPU: Core2Duo or later recommended • Gigabit Ethernet compatible computer recommended • Computer with RT ToolBox2 (Ver.3.00A or later) installed	1	For setting
(2)	LAN cable	Category 5e or higher	2	• Between computer and control unit • Between robot controller and control unit

◇◆◇If using a LAN hub◇◆◇
A Gigabit Ethernet compatible hub must be used. If a non-compatible hub is used between the computer and control unit, the display of live images at RT ToolBox2 will be delayed or stopped, and therefore caution is advised.

4.3. Software Version

In order to use MELFA-3D Vision, it is necessary that all software support MELFA-3D Vision. Check all versions prior to use.

■ Robot controller

Parts name	Model name	Compatible version
Controller	CR750-Q/CR751-Q	Ver.R6e or later Note1
	CR750-D/CR751-D	Ver.S6e or later Note1

Note 1: The upper limit of the recognized number of pieces for model-less recognition changes depending on the software version of the controller.

- Ver.R6e/S6e or later: Up to 50
- Ver.R6e/S6e or earlier: Up to 10

■ Supported software

Parts name	Model name	Compatible version
MELSOFT RT ToolBox2	3D-11C-WINJ 3D-11C-WINE	Ver.3.60N or later
MELSOFT RT ToolBox2 mini	3D-12C-WINJ 3D-12C-WINE	Ver.3.60N or later

5. CAMERA HEAD ATTACHMENT

5.1. Mounting base

The camera head is comprised of a projector, a camera, and a mounting base. It is necessary to select the appropriate mounting base (see "3.5 Camera Head Specifications") from the two available bases depending on the required workpiece distance and measurement view, and attach the projector and camera as shown in the drawing below [Note 1]. Secure the two projector angle adjustment screws.

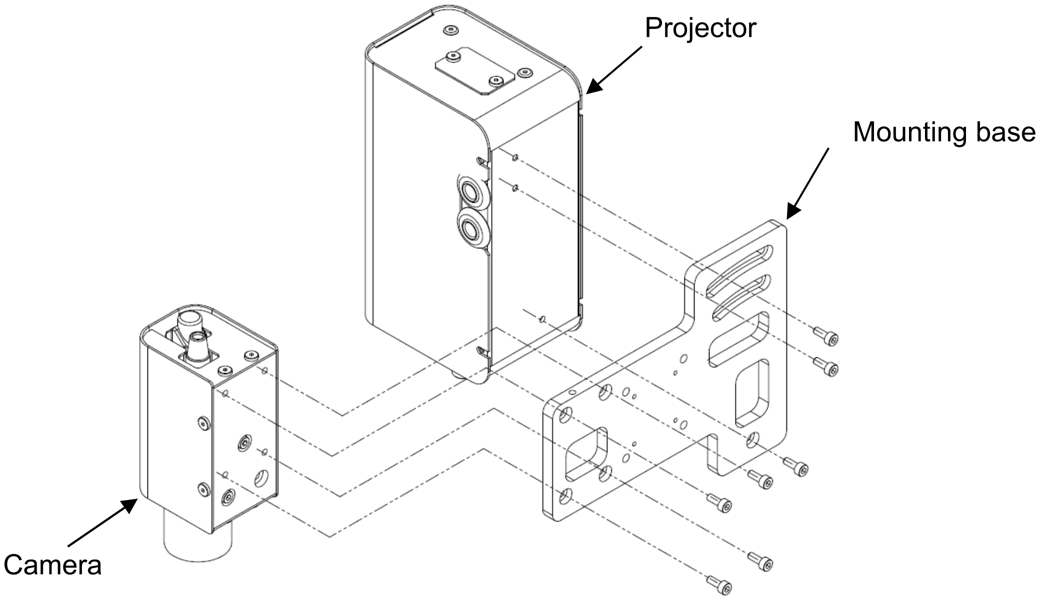


Fig. 5-1 Mounting base (small) attachment

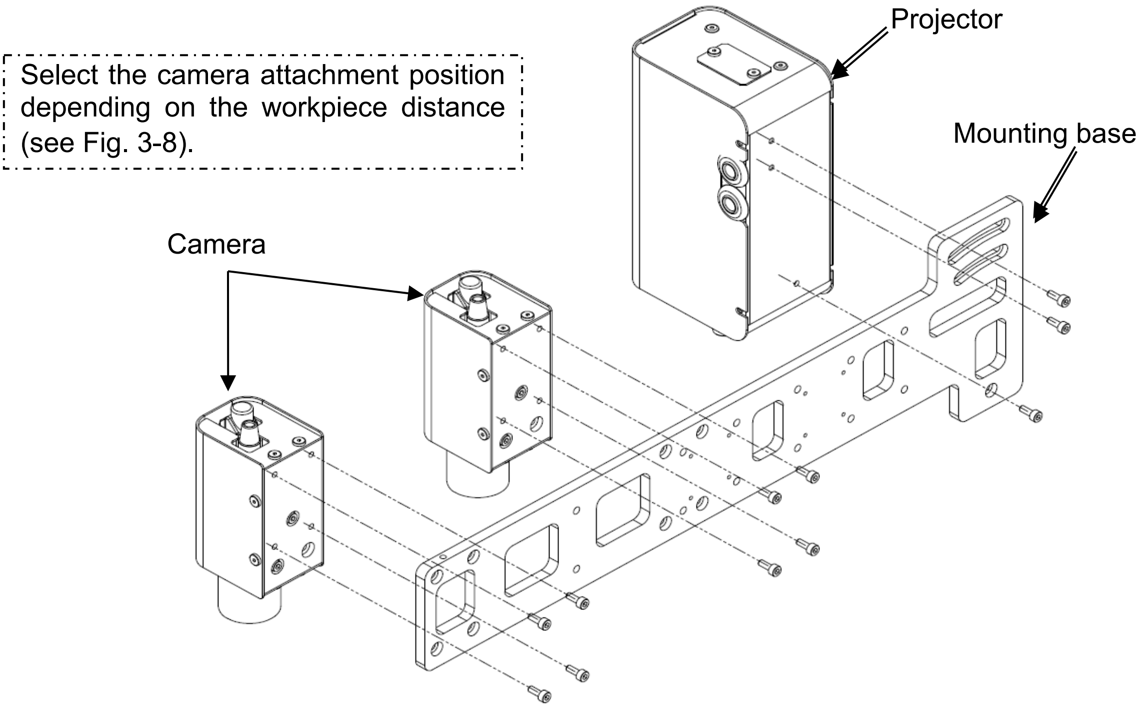


Fig. 5-2 Mounting base (large) attachment

Note 1: The mounting base (small) is already attached when shipped from the factory.

◇◆◇Camera head MAC address◇◆◇
When using multiple camera heads, they are identified with their MAC address. For the MAC addresses, see the default settings information sheet provided with the product. The MAC addresses can also be confirmed in the RT ToolBox2 MELFA-3D Vision settings screen.

When extended field of view option is attached

When extended field of view option is attached, please change the lens from f=12.5mm to f=9mm and attach the camera mounting base for horizontal installation. The base should be attached between the camera and original base in the direction of horizontal camera installation.

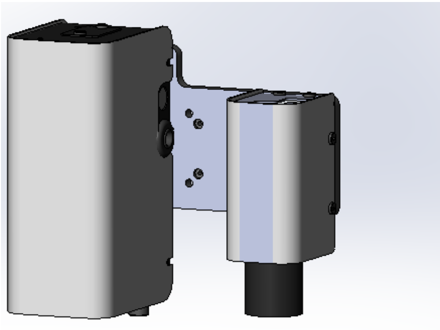


Fig. 5-3 Mounting base (large) attachment

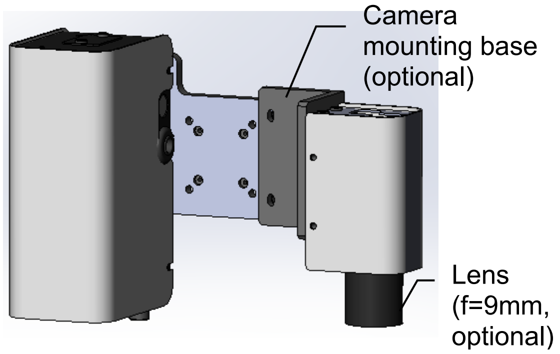


Fig. 5-4 Extended field of view option attached

5.2. Hand Eye

A camera head attachment adapter is required to attach the camera head to the robot. The customer is required to prepare the camera head attachment adapter.

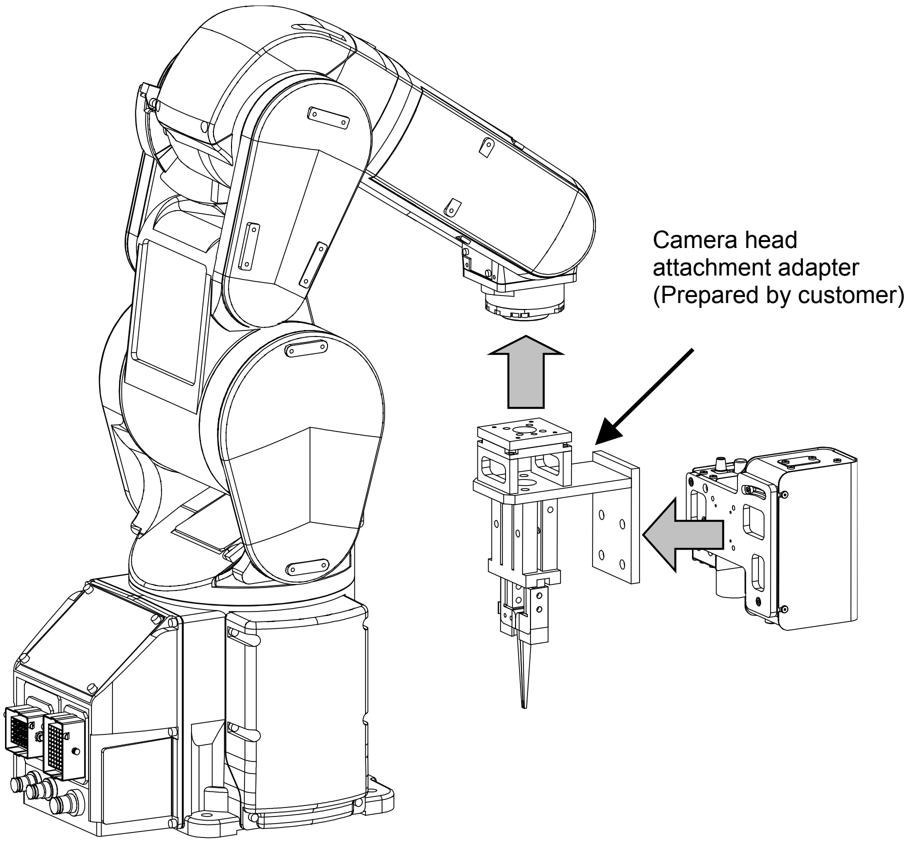


Fig. 5-5 Hand eye attachment example

◇◆◇Camera head posture when performing measurement◇◆◇

When performing measurement, use a digital spirit level, etc. and adjust the robot posture so that the camera front end flange surface is parallel (±0.5 [deg.] or less) to the measurement stand. Not doing so affects the measurement accuracy.

5.2.1. Hand eye merits and demerits

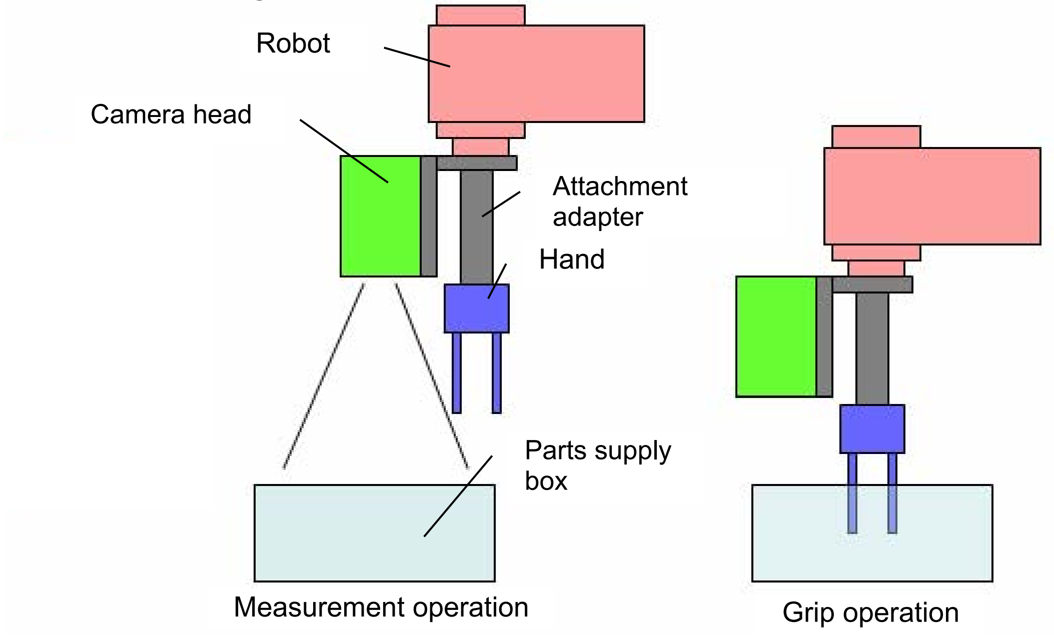


Fig. 5-6 Hand eye

<Merits>
(1) The measurement viewpoint can be moved freely with the robot, allowing multiple workpieces to be handled with ease.
(2) Long claws can be attached, making it easy to construct a layout in which interference with the parts supply box is difficult.

<Demerits>
(1) The robot rests when performing measurement, resulting in slowdown of the pace of work.
(2) The weight of transportable workpieces is limited by the weight of the camera head attachment adapter and the camera head.
(3) The robot posture is restricted because it is necessary to avoid the camera head interference area.

The hand eye is ideal for systems with multiple viewpoints such as those involving taking out of multiple workpieces. On the other hand, the increase in robot restrictions means that it is necessary to exercise caution when carrying out other tasks or when designing systems including the surrounding environment.

5.3. Fixed Camera

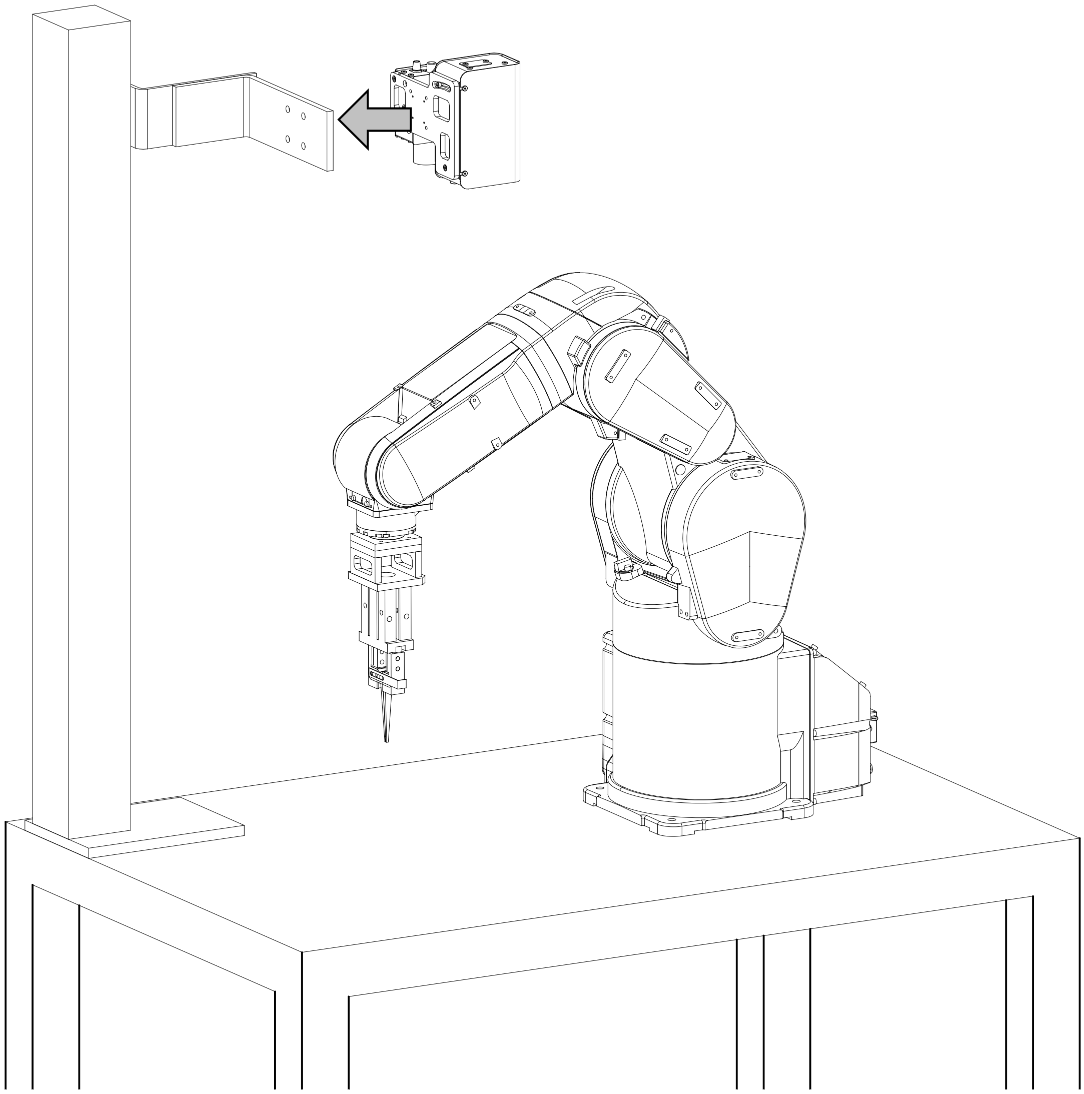


Fig. 5-7 Fixed camera attachment example

◇◆◇Camera head attachment posture◇◆◇
Use a digital spirit level, etc. and install the camera head so that the camera front end flange surface is parallel (±0.5 [deg.] or less) to the measurement stand. Not doing so affects the measurement accuracy.

5.3.1. Fixed camera merits and demerits

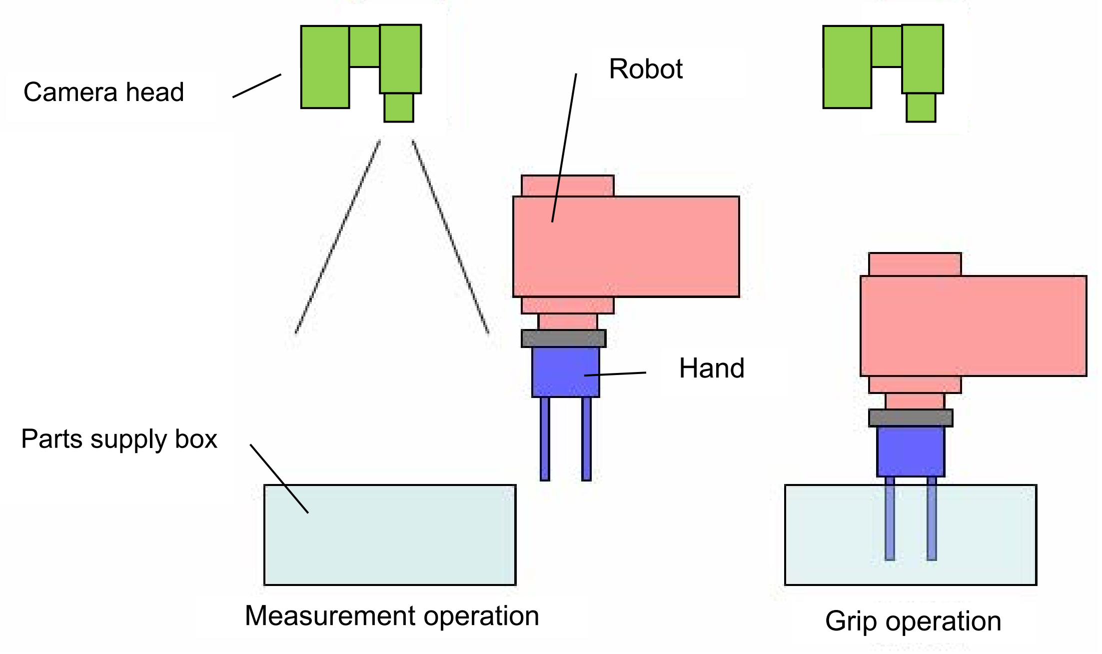


Fig. 5-8 Fixed camera

<Merits>
(1) Measurement is possible during robot movement, allowing cycle time to be reduced.
(2) There are few restrictions to transportable workpiece weight.

<Demerits>
A mechanism to drive the parts supply box or camera head is required to handle multiple workpieces.
The total length of the hand and robot must be shorter than the distance to the measurement stand.

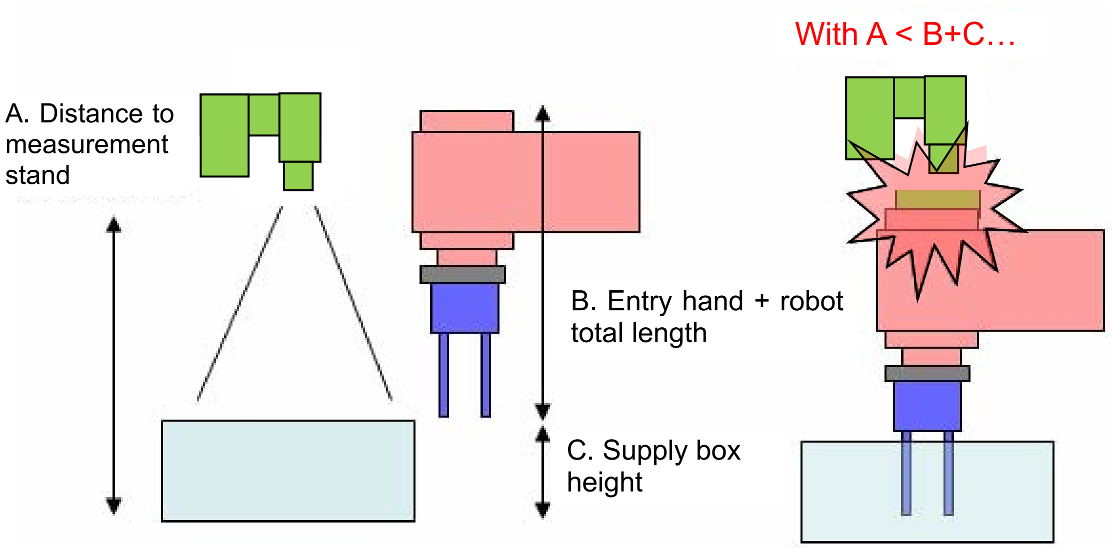


Fig. 5-9 Fixed camera demerits

As shown in the above figure, a collision will occur if the total length of the robot and the hand entering the workspace plus the height of the parts supply box is greater than the camera head workpiece distance (300 to 1,000 mm). Consideration is required for designing the system layout.

6. CONNECTION AND WIRING OF EQUIPMENT

This chapter describes the power cable and earth cable connection, remote power supply ON/OFF switch terminal block connection, camera head to control unit to robot controller connection, and wiring.

6.1. Power Cable and Earth Cable Connection

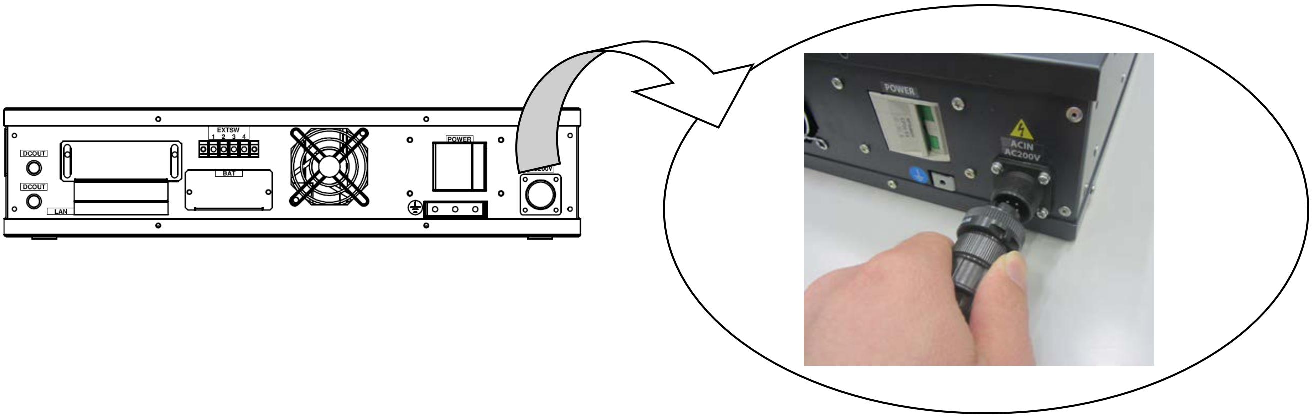
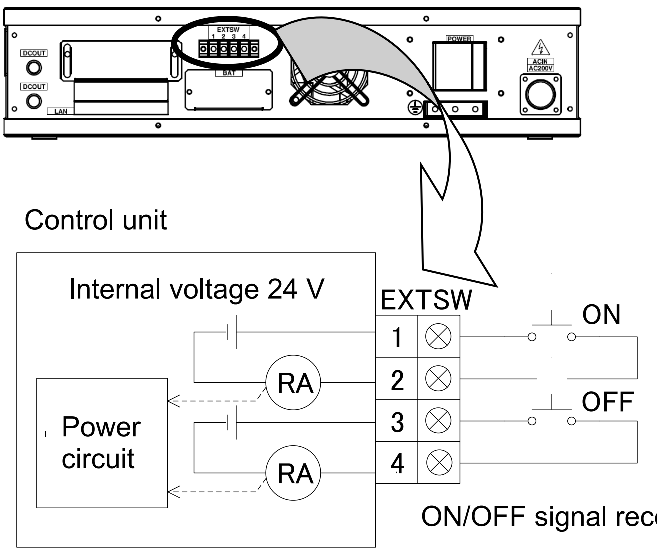


Fig. 6-1 Power cable and earth cable connection

6.2. Remote Power Supply ON/OFF Switch Terminal Block Connection

By installing a remote power ON/OFF switch outside the system panel when installing the control unit inside the panel, the control power for the control unit can be turned ON and OFF without opening the panel.



Connect the remote power supply ON/OFF switch cable to the terminal block with securing screws.
Screw size: M3
Crimped terminal: ϕ6 or smaller
Recommended product: 0.5 to 3 (J.S.T. Mfg. Co., Ltd.)
Wire size: AWG26 or smaller
Wire length: Prepare a cable with the length that ensures the control voltage is 21 V or higher.

ON/OFF signal receipt time: 50 ms or longer

Fig. 6-2 Remote power supply ON/OFF switch terminal block connection

⚠ CAUTION

When connecting the remote power supply ON/OFF switch cable to the EXTSW terminal block with a screw, hold down the crimped terminal while tightening to prevent it from rotating. The partition between terminals on the EXTSW terminal block may be damaged if force is applied.

6.3. Connection of Equipment

Connect the camera head, control unit, and robot controller as shown in Fig. 6-3 to Fig. 6-5.

◇◆◇Robot controller connection◇◆◇
If performing measurement and recognition only, there is no need to connect the robot controller. If performing picking work, connect the robot controller.

<CR750-D series>

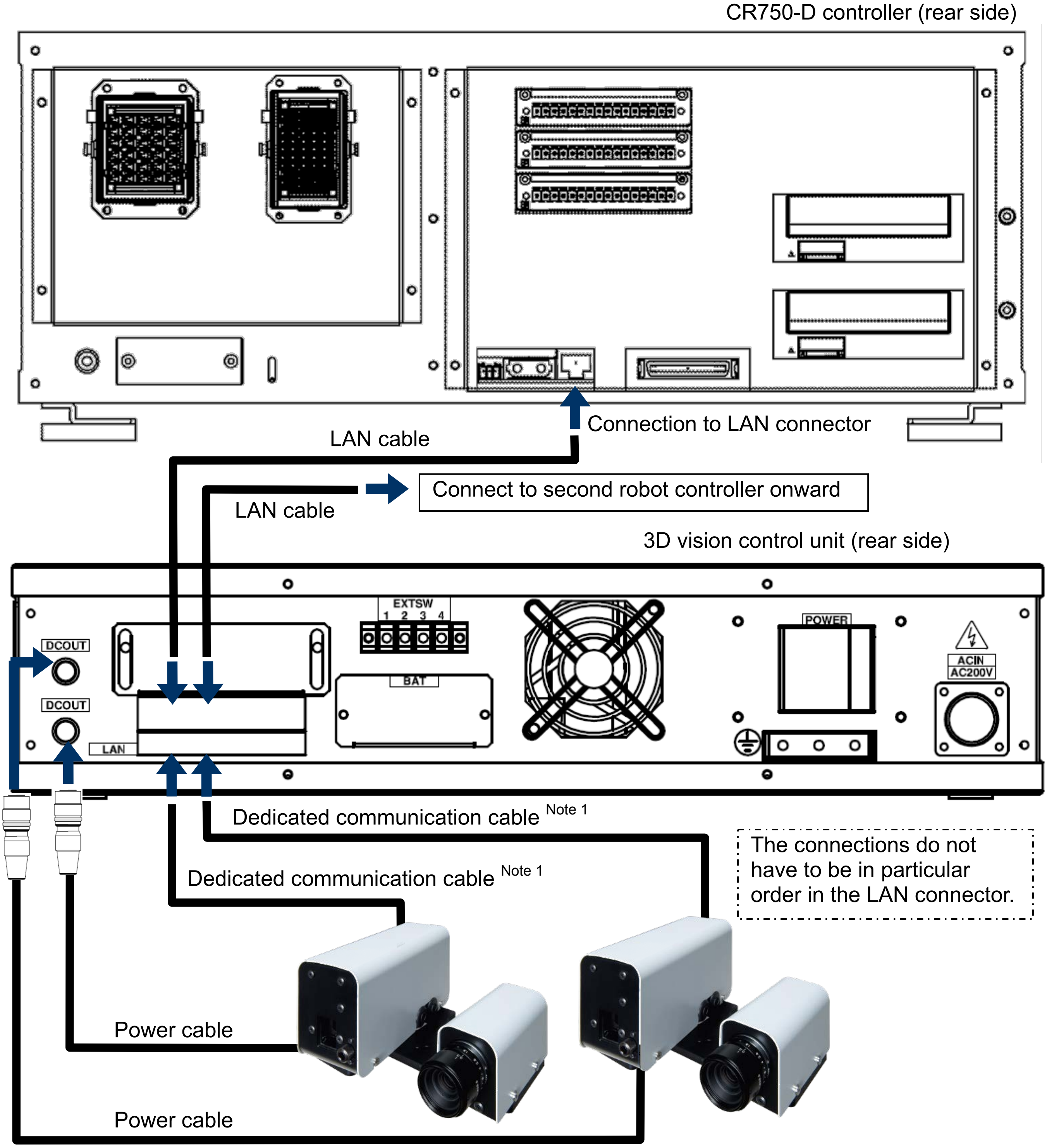


Fig. 6-3 Cable connection (CR750-D series)

Note 1: Connect the dedicated communication cable directly to the control unit without routing it through a hub.

<CR751-D series>

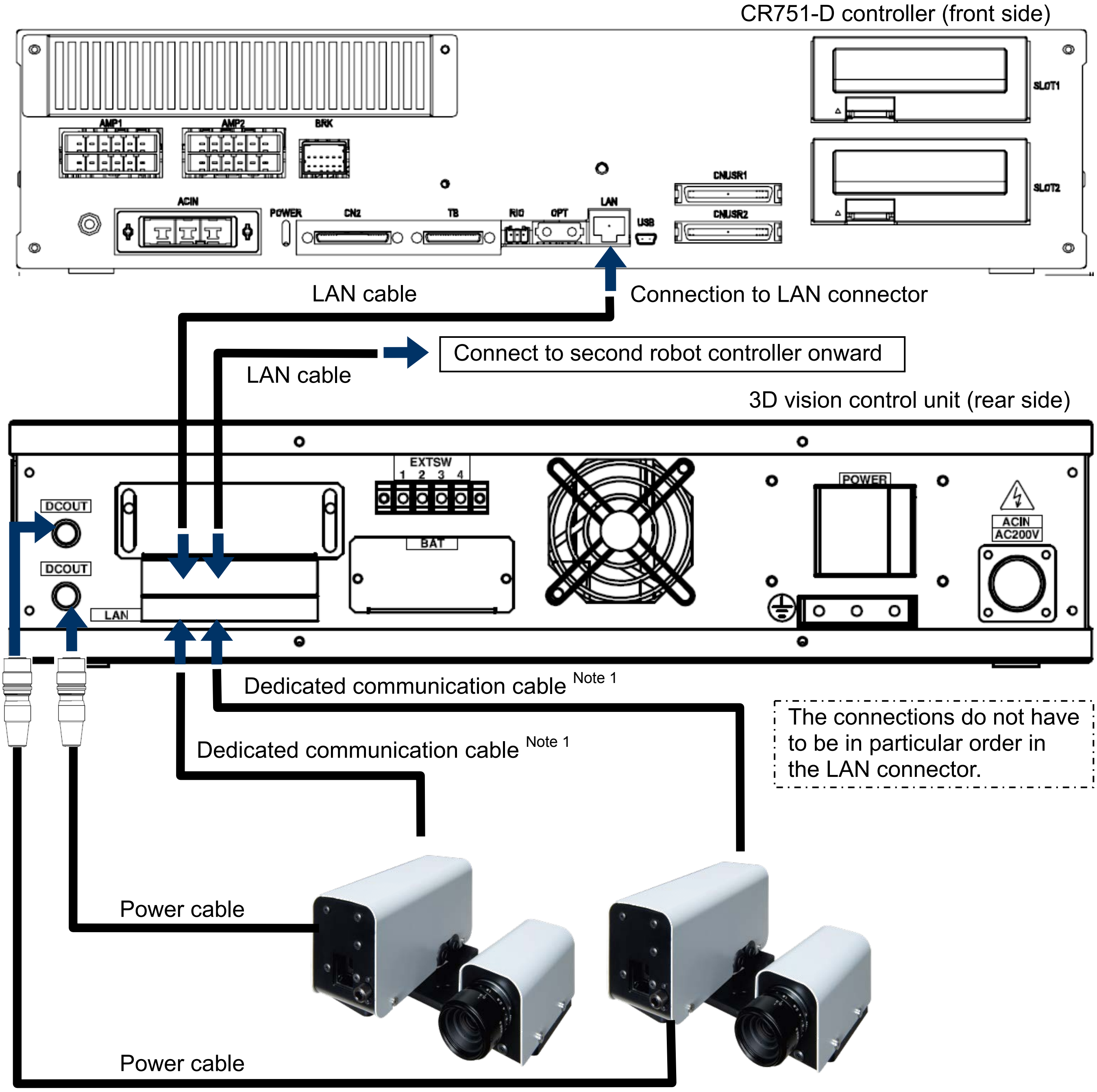


Fig. 6-4 Cable connection (CR751-D series)

Note 1: Connect the dedicated communication cable directly to the control unit without routing it through a hub.

<CR750-Q/CR751-Q series>

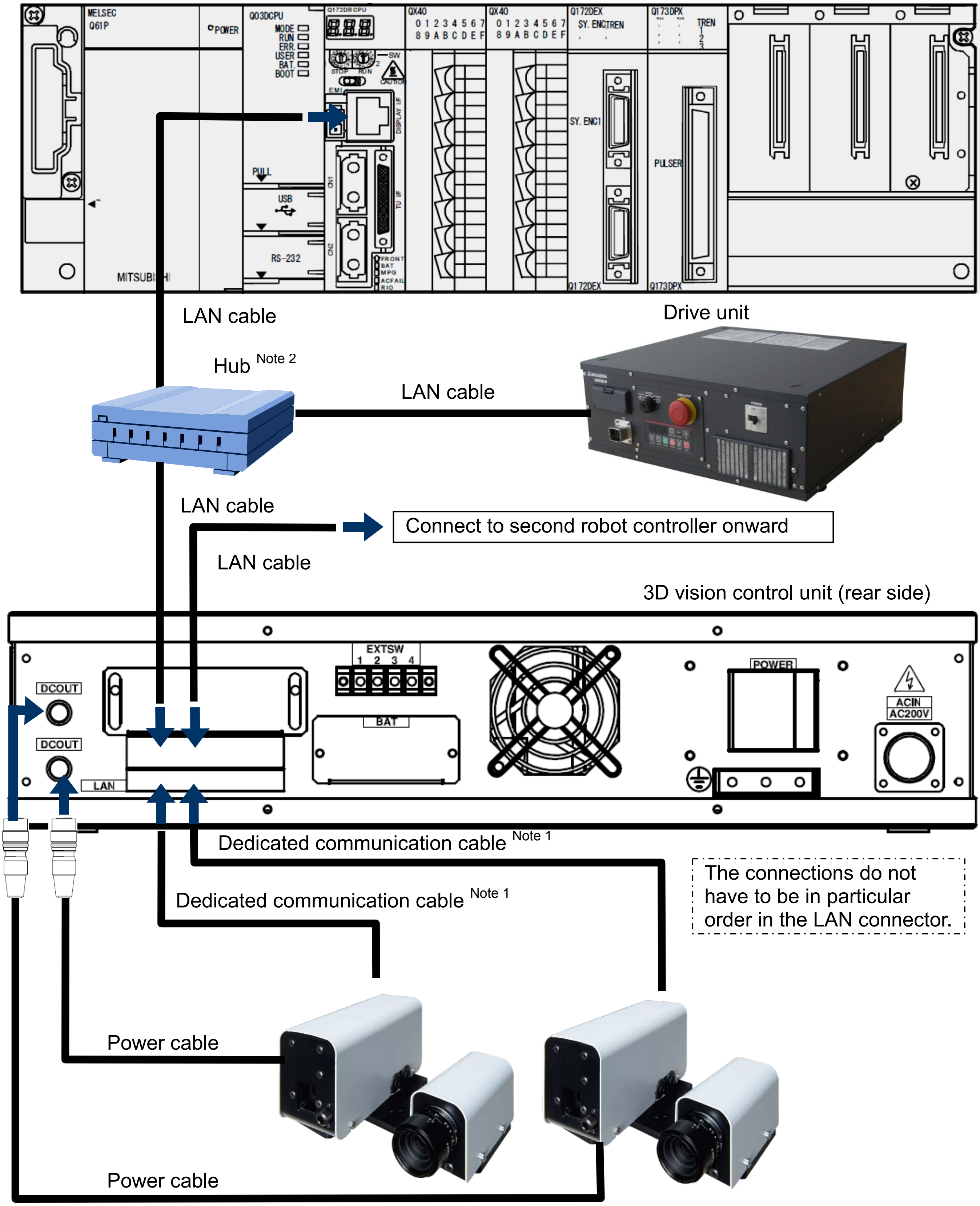


Fig. 6-5 Cable connection (CR750-Q/CR751-Q series)

Note 1: Connect the dedicated communication cable directly to the control unit without routing it through a hub.

Note 2: The hub is not required if the control unit LAN connector is available. Use of a hub can be avoided by connecting the Q172DRCPU and drive unit LAN cable directly to the control unit LAN connector.

6.4. Wiring of Equipment

Wire the control unit and camera head as shown in the following figure.

6.4.1. Hand eye

Secure the power cable and dedicated communication cable between the control unit and camera head to the outer periphery of the robot. When doing so, secure so that the cable is not stretched when the robot moves. Please note that this system is **not compatible with internal wiring specifications**.

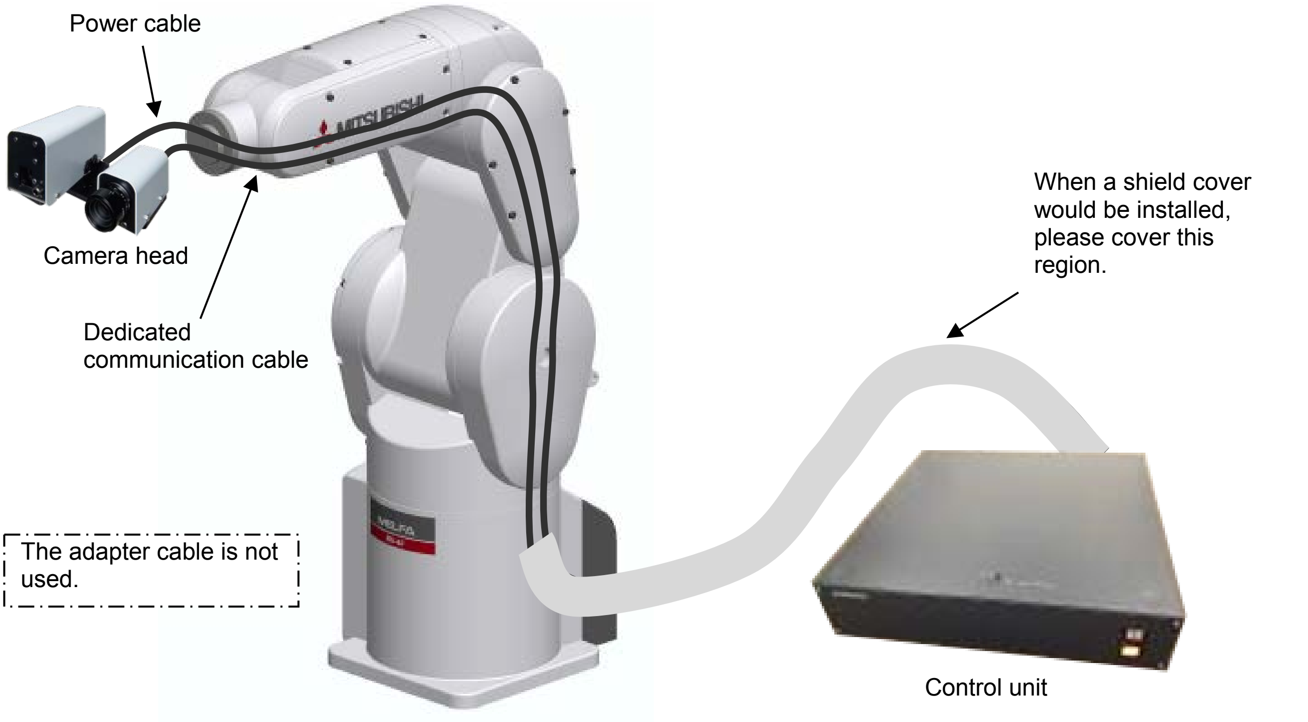


Fig. 6-6 Wiring example for hand eye

6.4.2. Fixed camera

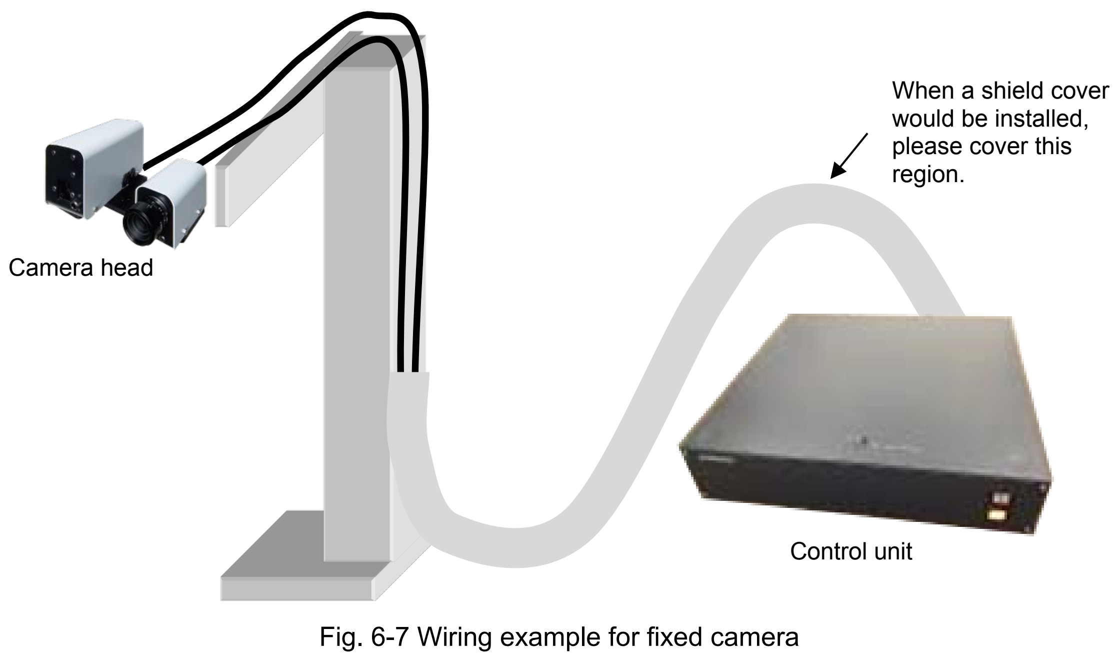


Fig. 6-7 Wiring example for fixed camera

7. USING MELFA-3D VISION

7.1. IP Address Preparation

A separate IP address is required for both the control unit and the camera head. If connecting to a network, contact the network administrator beforehand to obtain IP addresses.

7.2. Turning ON the Power

Power ON

After turning ON the control unit main power switch, turn ON the power switch. By turning ON the power switch, the start screen shown in Fig. 7-1 appears. After turning ON the power switch, **it takes about 50 seconds before the system is ready**. If the camera settings have been completed, pattern irradiation is performed only once from the camera head when the system gets ready. The system ready condition can be also checked by the following.

- The status is displayed on the Control unit setting/addition screen (see 7.5).
- By double-clicking the control unit added to the workspace, the MELFA-3D Vision setting screen appears (see 7.5).
  * If the system is not ready, nothing appears even after performing the above steps.
- While the MELFA-3D Vision setting screen is displayed, the system status can be checked by the property monitor connection status (see 7.5).

Please note that the control unit and the robot controller power can be tuned ON in any order.

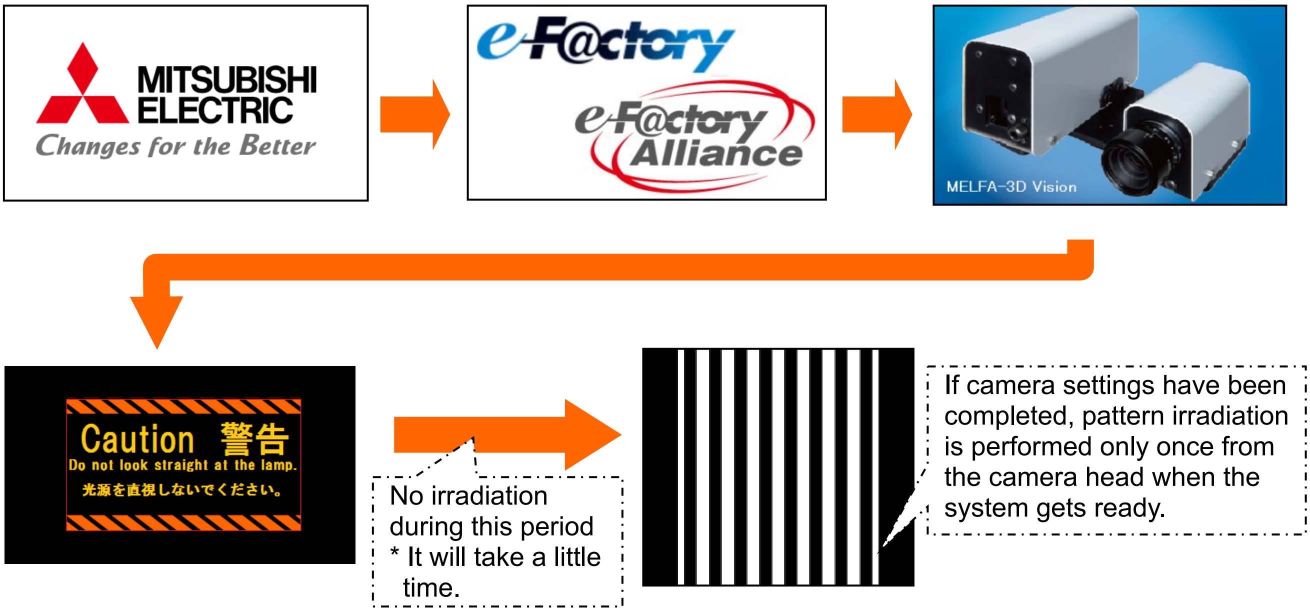


Fig. 7-1 Start screen at the time of power-on

◇◆◇Behavior until system ready for use◇◆◇

- At RT ToolBox2, the system is handled as if the connection has been severed.
- If an attempt is made to connect to the control unit with a robot program, an L3142 "Unable to open communication line" error will occur.

Power OFF

Press the control unit power OFF switch. Wait a short while as the system shuts down after pressing the control unit power OFF switch. The control unit fan stops when the process is completed. Then, turn OFF the main power switch. Please note that the control unit and robot controller power can be tuned OFF in any order.

⚠ **CAUTION**

The control unit is equipped with an HDD. If the main power is turned OFF without waiting for processing to finish, the HDD may be damaged. Always turn the main power OFF after processing is finished.

7.3. RT ToolBox2 Startup

RT ToolBox2 is required to specify MELFA-3D Vision settings. Double-click the desktop shortcut to start RT ToolBox2, or click the [Start] button, and select [All programs] - [MELSOFT] - [RT ToolBox2].

Fig. 7-2 RT ToolBox2 shortcut

7.4. Robot Ethernet Settings

With the sample robot program contained in the CD-ROM (4F-3DVS2-CD) provided, "COM2:" is used for communication with the robot. If using with the COM port setting as is, specify settings as shown in Table 7-1.

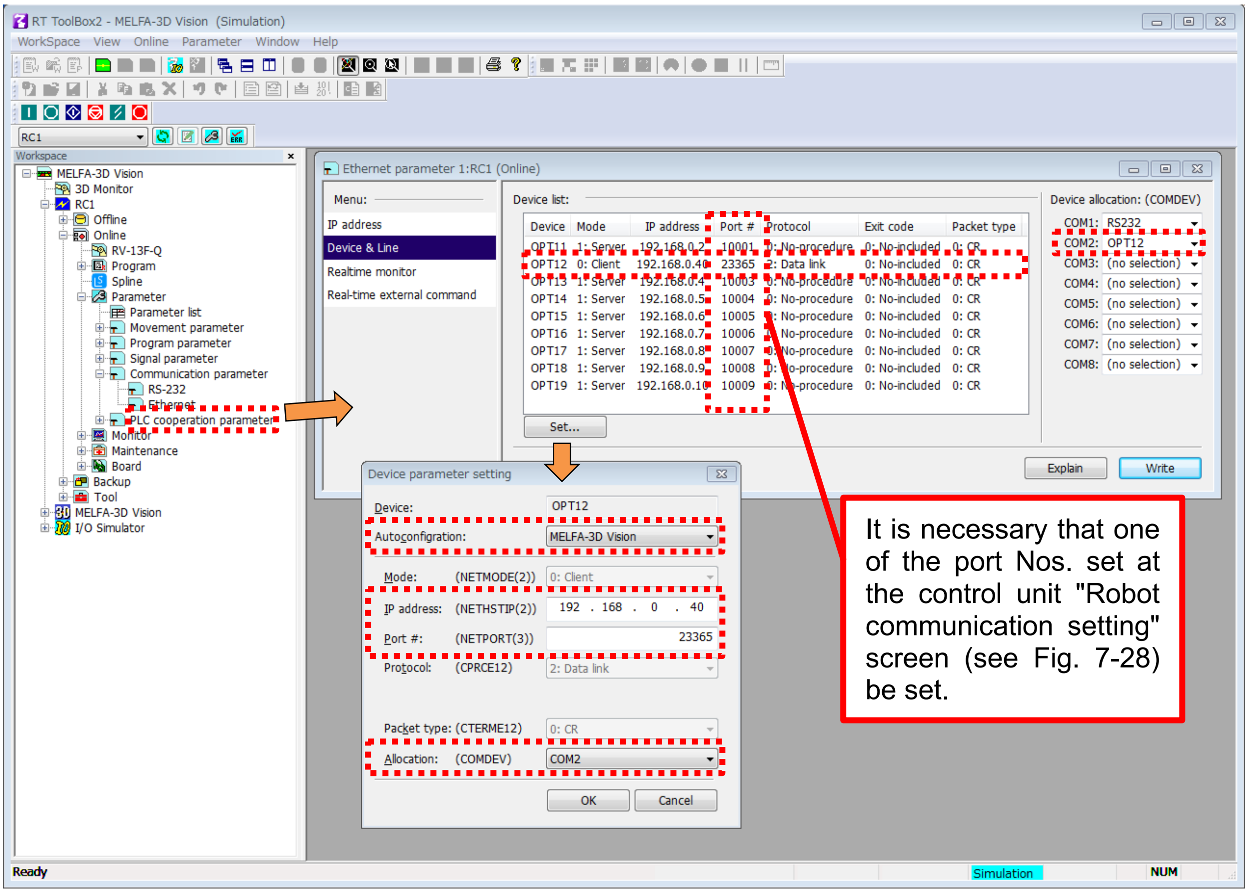


Fig. 7-3 Ethernet setting screen for robots

Display the Ethernet parameter screen by clicking [Online] from a project tree - [Parameter] - [Communication parameter] - and double-clicking [Ethernet]. Then, display the list of devices by clicking [Device & Line]. Select the device to be set and click settings. Next, configure the settings as follows.

Table 7-1 Ethernet configuration example for robots

No.	Parameter name	Setting value	Definition
1	Autoconfiguration	MELFA-3D Vision	Select [MELFA-3D Vision] from the selection field.
2	IP address (NETHSTIP(2))	192.168.0.40	Select the IP address for the control unit.
3	Port # (NETPORT(3))	23365	Select the port number for the control unit Note1 .
4	Allocation (COMDEV)	COM2	Select the serial port number from the selection field.

Note 1: Set to the same port No. (see 7.5 Setting and Adding Control Units) as entered in the control unit communication settings.

Click [OK] - [Write] to write to the robot controller and then reboot.
* Change the robot controller IP address as required depending on the working environment.

7.5. Setting and Adding Control Units

Control unit setting/addition screen display

Specify communication settings for the control unit used and add to the workspace. By creating a workspace at RT ToolBox2, [MELFA-3D Vision] appears in the project tree. By pointing [MELFA-3D Vision], [Control unit setting/addition] appears. Double-click this item.

A Control unit setting/addition screen then appears displaying control units that exist on the network. If no control units appear, check whether the control unit power is ON, and check the connection with the computer and the firewall settings (see 10.3 Q&A No.1). Furthermore, after turning ON the control unit power switch, **it takes approximately 50 seconds before the system is ready**. Wait a while until the [Setting and Add Control unit] screen appears when the control unit is ready.

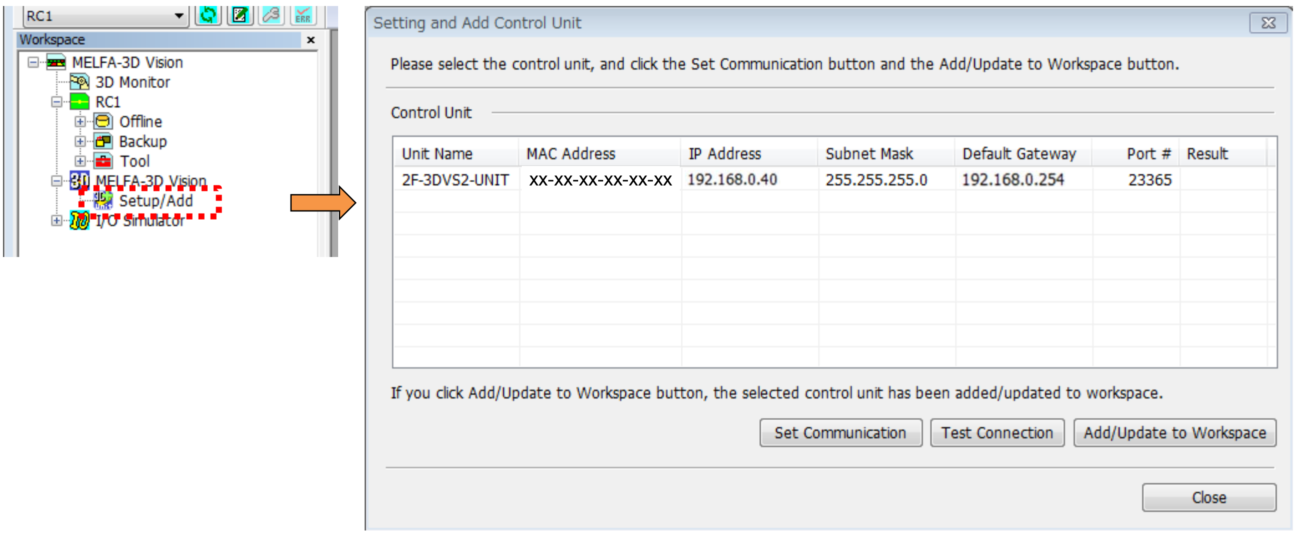


Fig. 7-4 Setting/registration of the control unit

Control unit communication settings

To specify control unit communication settings, select a control unit from the list, and then click the [Set Communication] button to display a control unit communication settings screen. When doing so, identify the control unit by referring to the MAC address entered in the default settings information sheet.

The unit name is set to identify the control unit. This unit name also appears in the tree when the control unit is added to the workspace. Change as required. [Note 1] Note that the initial setting of the control unit name is [2F-3DVS2-UNIT] or [2F-3DVS2-UNIT2].

By clicking the [Copy these computer settings] button, the network part of the IP address, subnet mask, and default gateway set at the computer are copied to the respective fields. Enter the host part of the IP address so that it does not overlap with devices such as robot controllers or computers within the same network. If, for example, the subnet mask is 255.255.255.0, ensure that the ∆ part of IP address □□□.□□□.□□□. ∆∆∆ does not overlap with other devices. Furthermore, ensure that the port No. is the same as that set in 7.4.

When entry of all items is completed, click the [Set] button to set the communication settings in the control unit. Please note that if changes are made to the IP address, subnet mask, or default gateway, the control unit will restart automatically. **It takes about one minute for the control unit to restart**. Wait for a while to change the communication settings again.

◇◆◇Restarting the control unit◇◆◇
If only the control unit is restarted, turning ON of the robot controller power again is not required.

Note 1: Up to 32 single-byte alphanumeric characters, single-byte spaces, and symbols (except ¥/:*?”<>|)

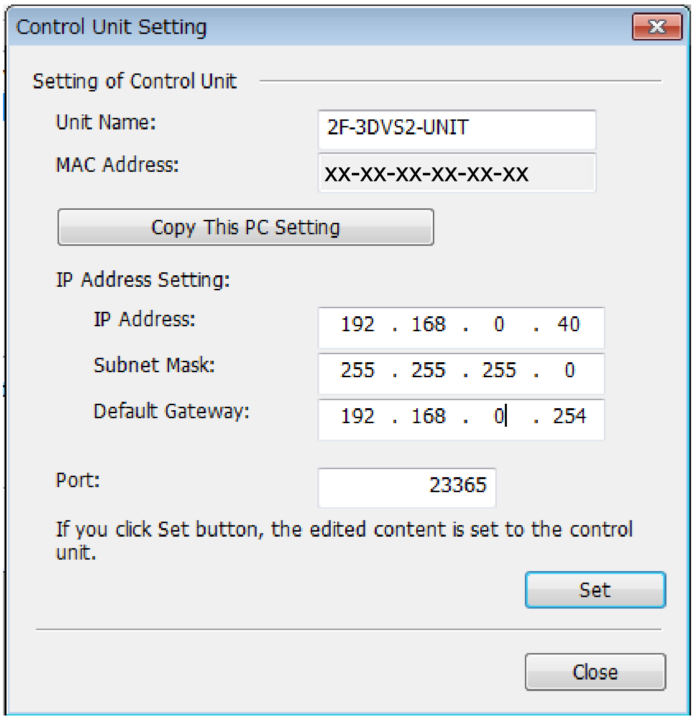


Fig. 7-5 Communication settings of the control unit

<u>Adding the control unit to the workspace</u>
When communication settings are completed, a dialog box appears, asking the user to select whether to add the control unit to the workspace. If there are no problems with the communication settings, click the [Yes] button.

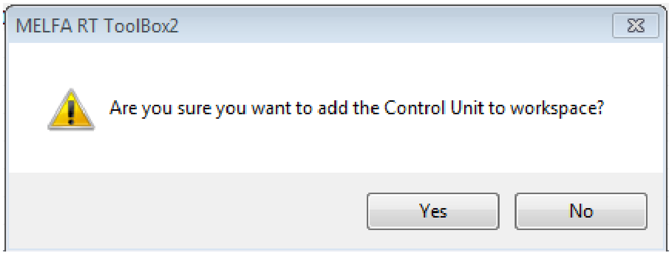


Fig. 7-6 Confirmation of the addition to the work space of the control unit

If adding a control unit for which communication settings are completed to the workspace, select the control unit to be added from the list, and then click the [Add/Update to Workspace] button to add the selected control unit to the workspace.

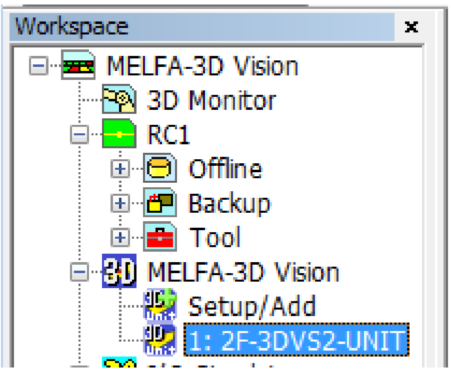


Fig. 7-7 Addition of the control unit to the work space

Connection test

Select the control unit added at the Control unit setting/addition screen and then click the [Test Connection] button to perform a connection test for the selected control unit. If the connection test result is OK, close the [Setting and Add Control Unit] screen. If the test fails, check the communication settings.

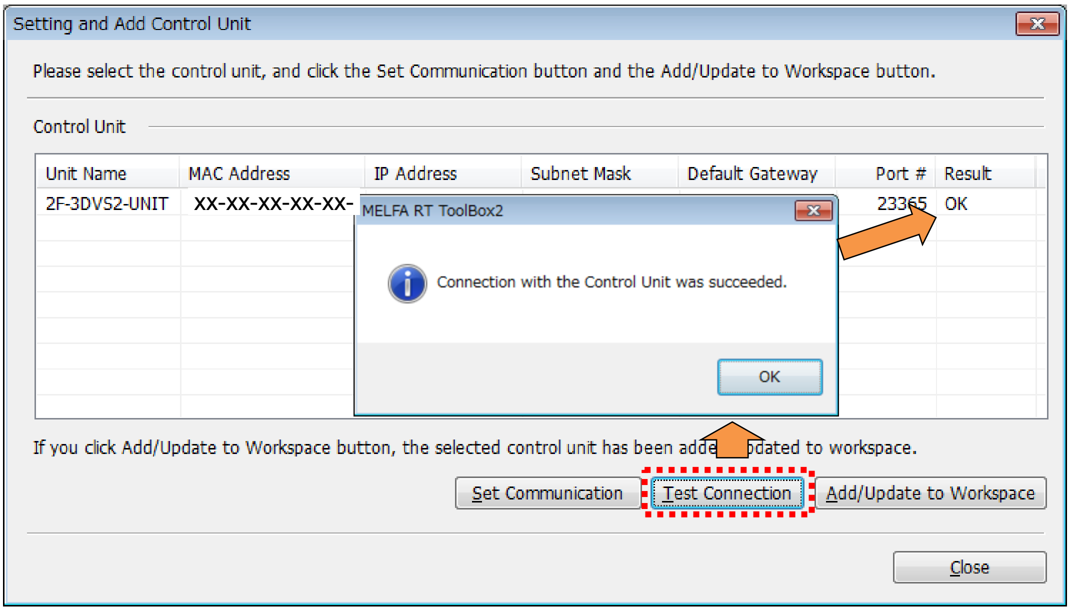


Fig. 7-8 Connection test for the control unit

MELFA-3D Vision setting screen display

By double-clicking the control unit added to the workspace, a MELFA-3D Vision setting screen appears (see Fig. 7-9).

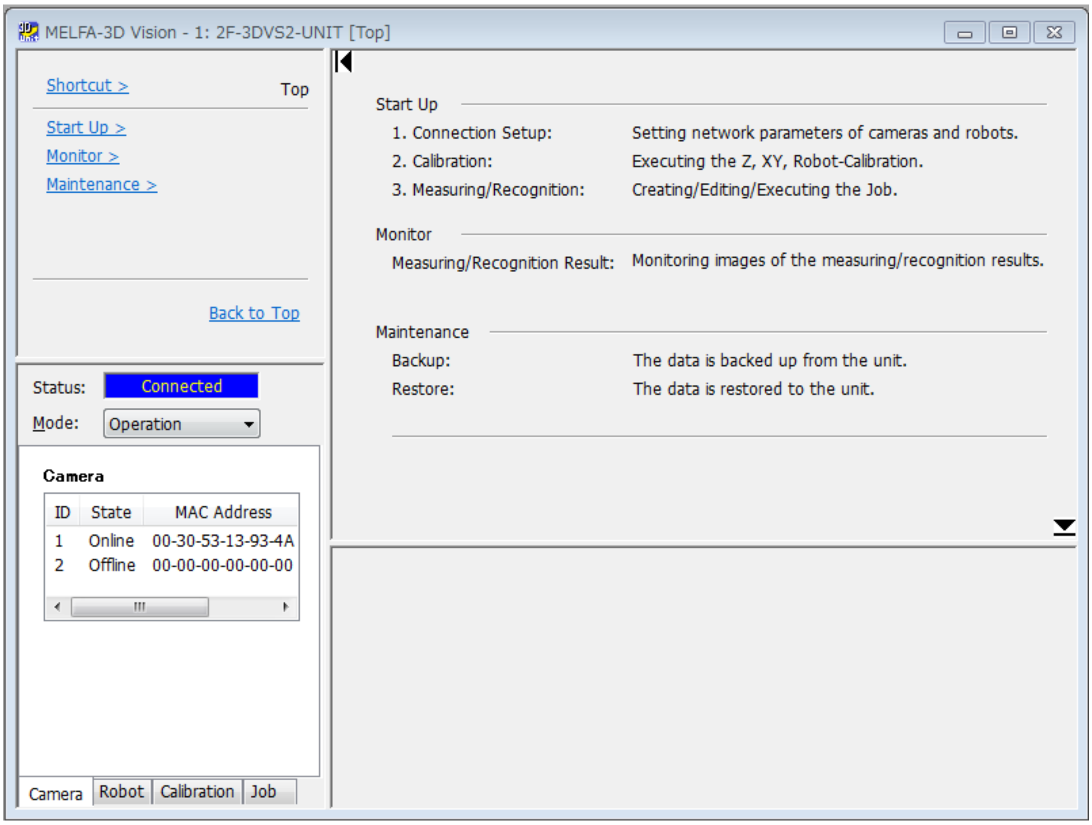


Fig. 7-9 Setting screen for MELFA-3D Vision

7.6. MELFA-3D Vision Setting Screen Description

The MELFA-3D Vision setting screen is configured as follows.

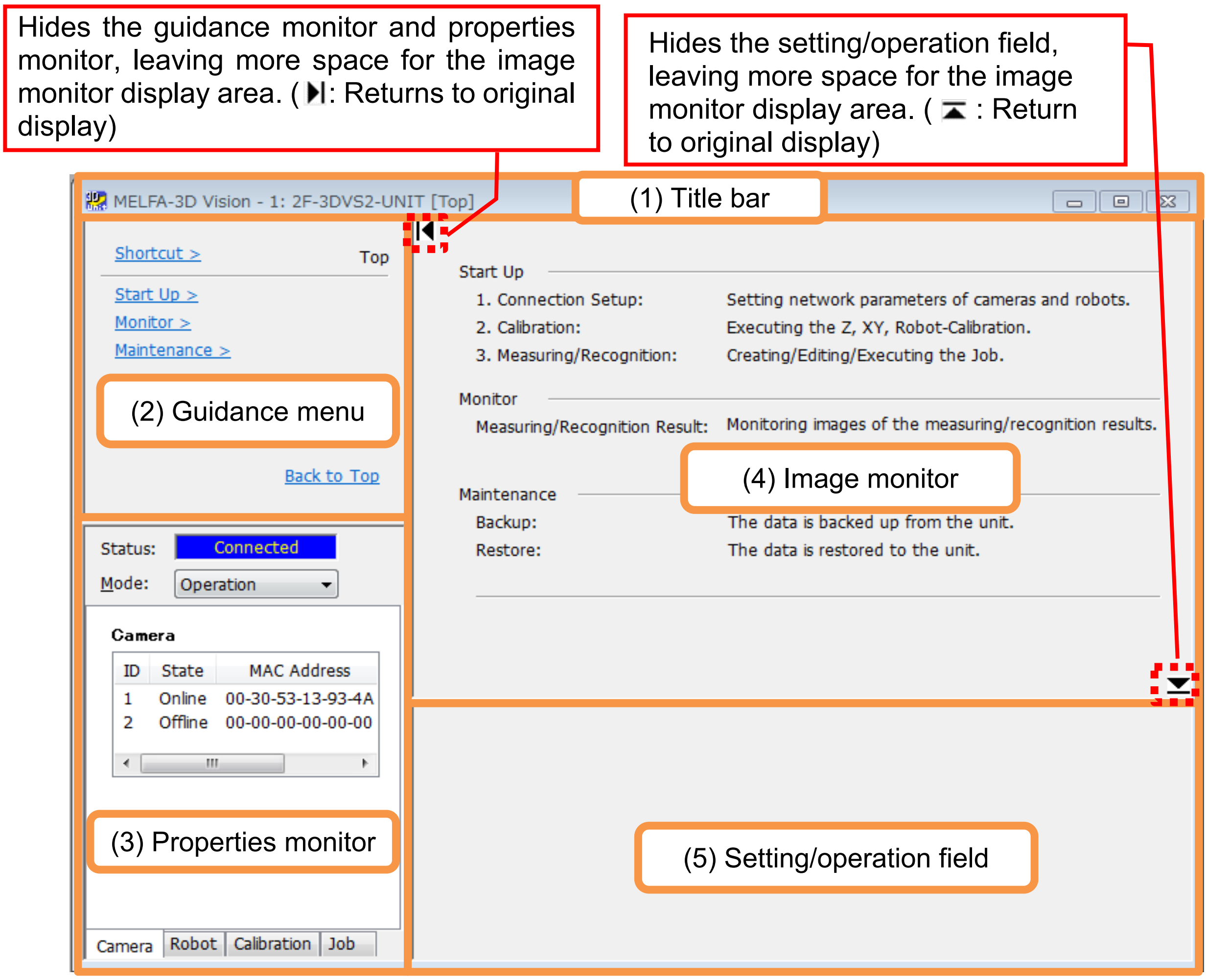


Fig. 7-10 Instructions for the MELFA-3D Vision setting screen

7.6.1. Title bar

The title bar displays the following information.

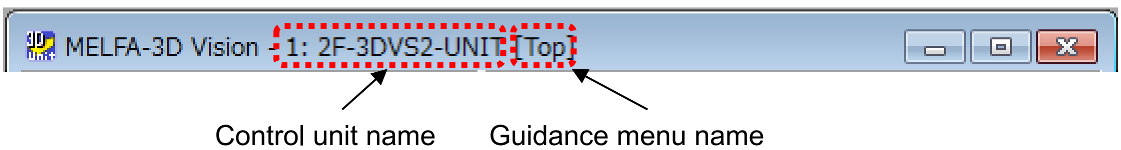


Fig. 7-11 Notation of the title bar for the MELFA-3D Vision setting screen (1)

When creating, editing, or executing calibration data or jobs, the applicable calibration data name or job name is displayed after the guidance menu name.

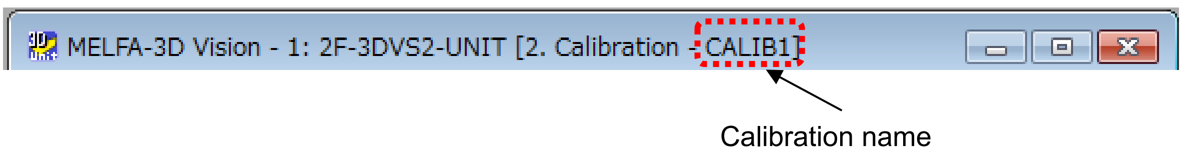


Fig. 7-12 Notation of the title bar for the MELFA-3D Vision setting screen (2)

7.6.2. Guidance menu

Menus are classified into startup, operation (monitor), and maintenance based on purpose, and respective menu screens are displayed by clicking links.

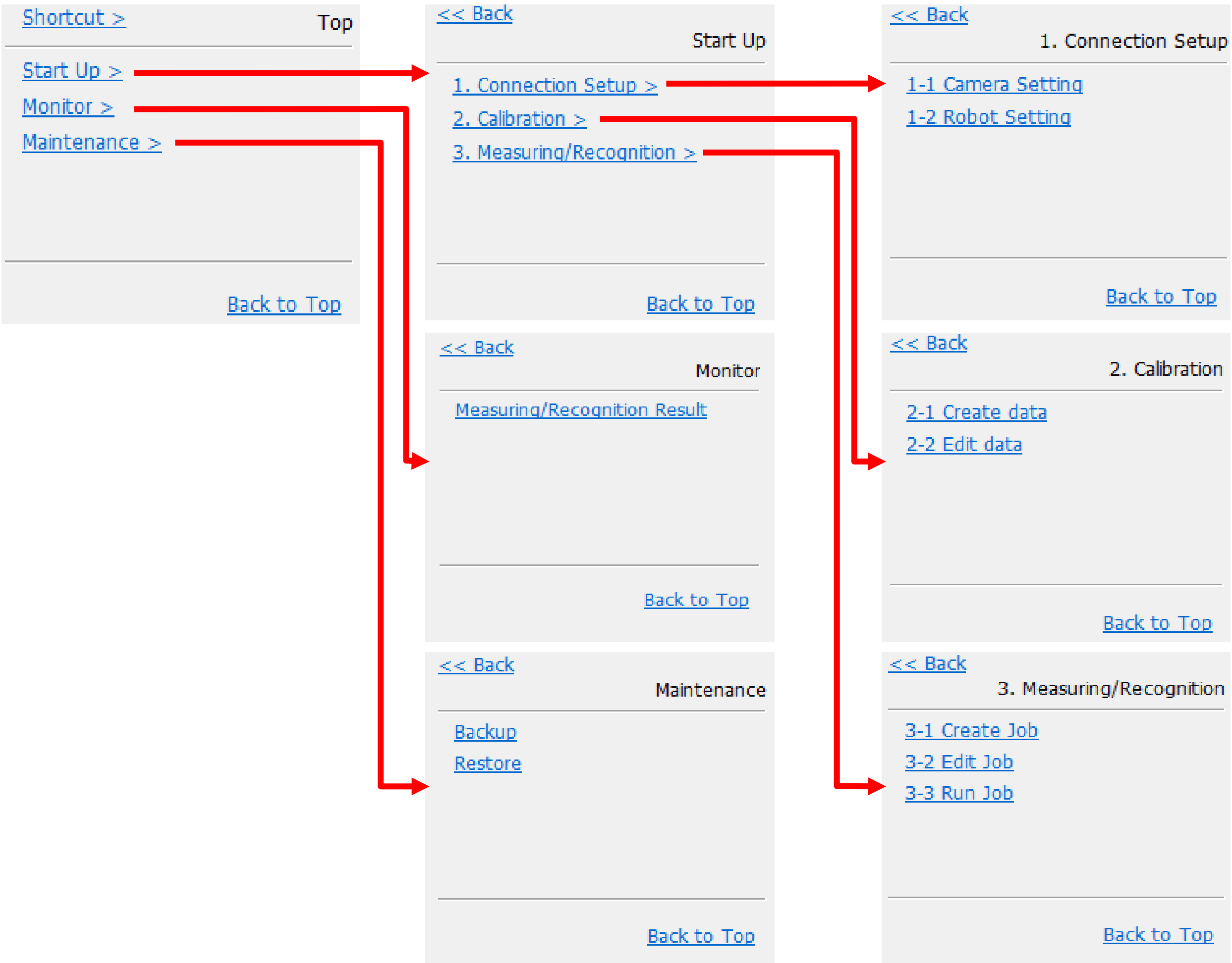


Fig. 7-13 Guidance menu screen transition

By clicking the [Shortcut] link, a screen appears to display all menus in a list.

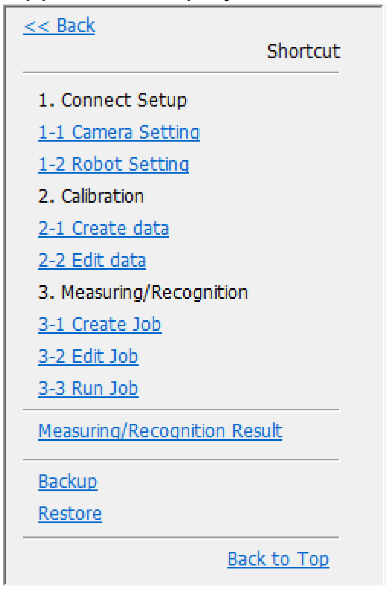


Fig. 7-14 Guidance menu shortcuts

7.6.3. Properties monitor

In the properties monitor, camera connection settings, robot connection settings, calibration data, and job data information are displayed.

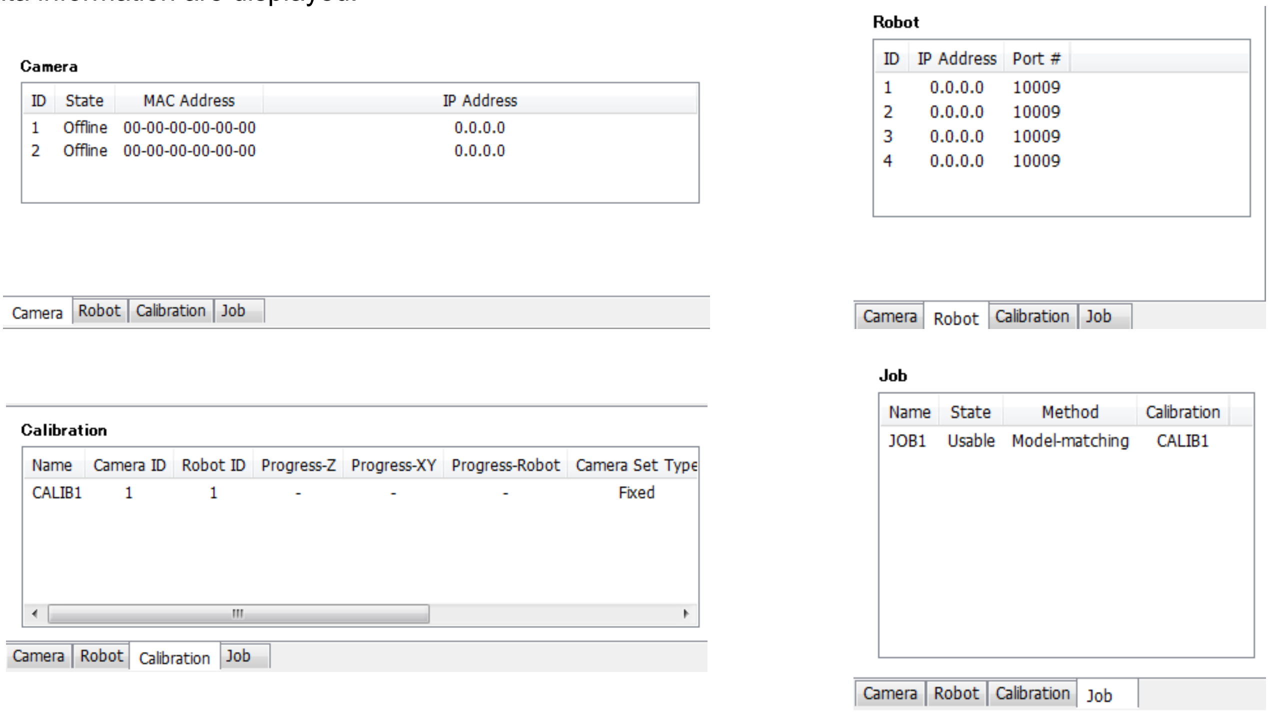


Fig. 7-15 Property monitor

The properties monitor can also be used to check the status of the connection with the control unit, and to change the operation mode from a drop-down menu.

Fig. 7-16 Control unit connection status

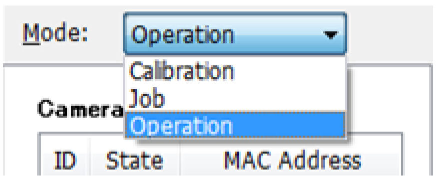


Fig. 7-17 Operation mode change

◇◆◇Operation modes◇◆◇

Operations modes are described in the following table.

Operation mode	Description
Calibration	No requests other than calibration commands from the robot controller are accepted.
Job	No requests are accepted from the robot controller.
Operation	All requests other than calibration commands from the robot controller are accepted.

Camera tab
From the context menu that appears by right-clicking the Camera tab, live images can be displayed.

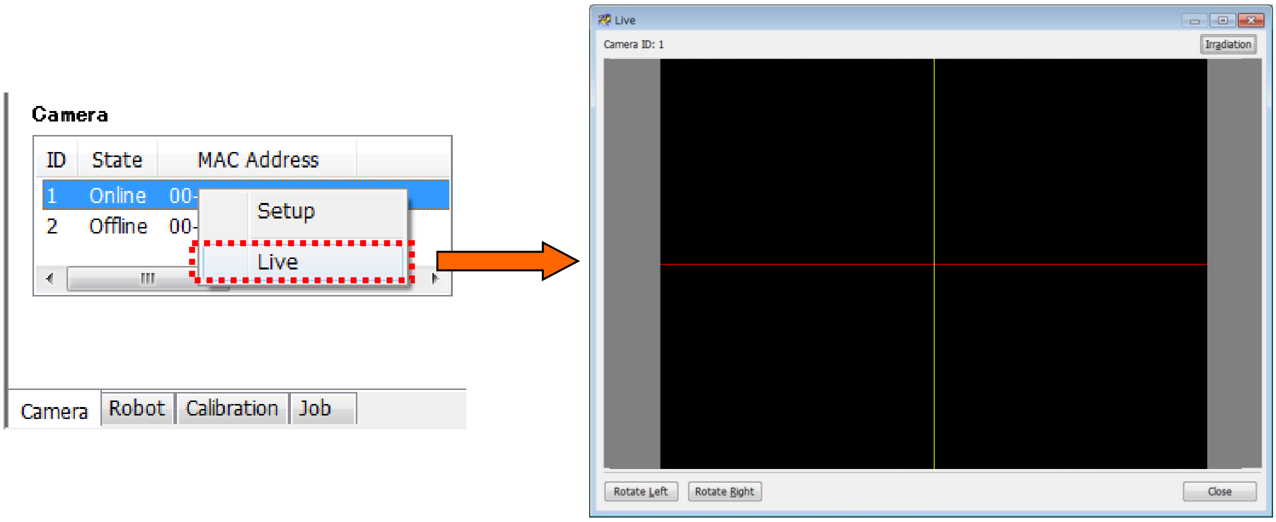


Fig. 7-18 Live image

7.6.4. Image monitor

In the image monitor, images such as live images, pattern images, measurement results (range images), and recognition results are displayed.

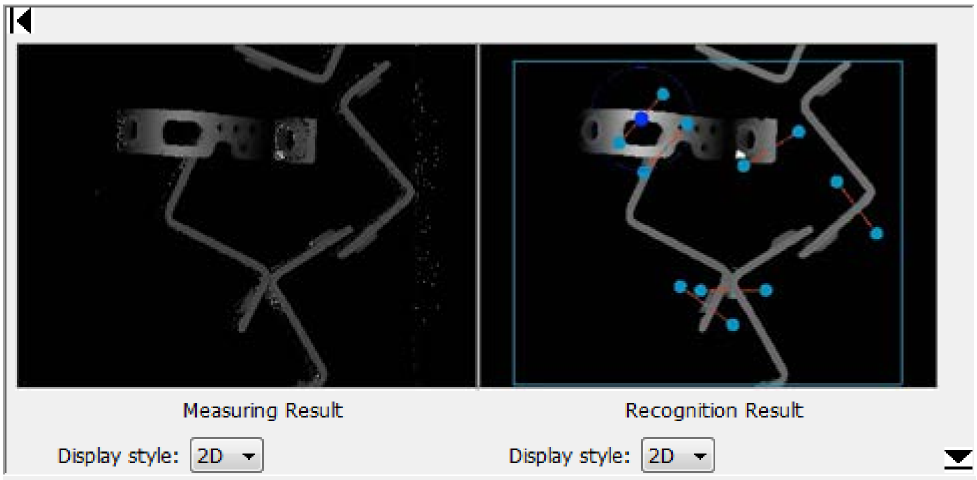


Fig. 7-19 Image monitor

The image center on 2D images displayed at the monitor is the XY origin of the camera coordinate system (see Fig. 3-9).

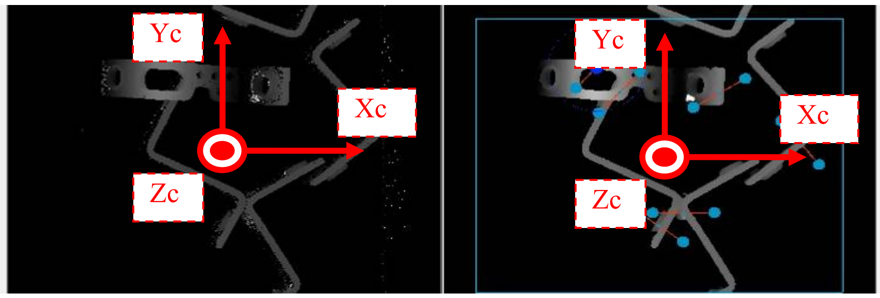


Fig. 7-20 Camera coordinate system in image monitor

By selecting "3D" for the display format, measurement and recognition results can be displayed in 3D. The viewpoint can be changed using the mouse (see Table 7-2).

Table 7-2 Mouse operation to change image monitor (3D display) viewpoint

Viewpoint change	Mouse operation at graphic display
Viewpoint rotation	While left-clicking, move left and right to rotate around the Z-axis. Move up and down to rotate around the X-axis. While clicking the left and right buttons, move left and right to rotate around the Y-axis.
Viewpoint movement	While right-clicking, move up, down, left, and right.
Enlarging/reducing graphic images	While holding down the [SHIFT] key and left-clicking, move up and down.

Furthermore, by selecting the texture display check box, 2D images captured by the camera are mapped and displayed over 3D data.

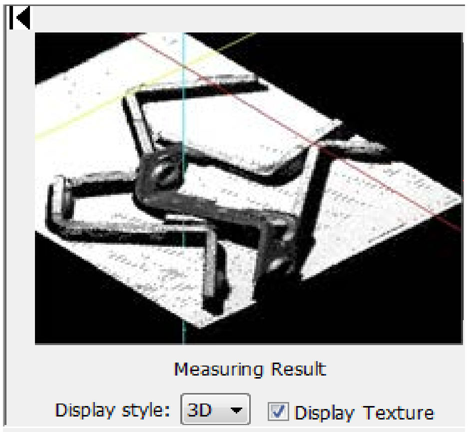


Fig. 7-21 Image monitor (3D display)

7.6.5. Setting/operation field

A Setting/operation screen according to the operation is displayed in the setting/operation field.

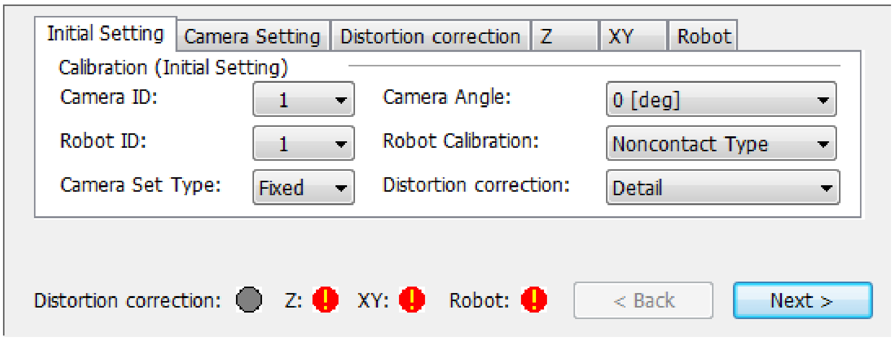


Fig. 7-22 Calibration setting/operation field

7.7. Connection Settings

7.7.1. Camera settings

Camera settings screen display

This screen is used to specify camera communication settings. By clicking [Startup] - [1. Connection Setup] - [1-1 Camera setting] in the guidance menu in the MELFA-3D Vision setting screen, a Camera settings screen appears. By clicking the [Refresh] button, the latest information from the control unit is acquired.

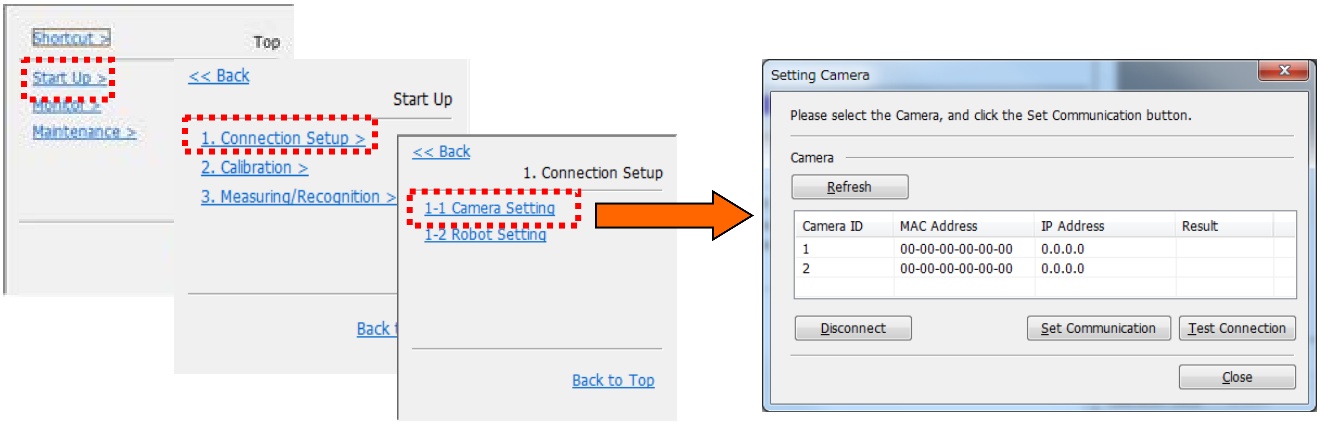


Fig. 7-23 Camera settings

Camera communication settings

Up to two cameras can be connected to a single control unit. The two cameras are identified by their camera ID. By selecting the camera ID for the camera to be registered and then clicking the [Set Communication] button, the Camera communication settings screen appears. Select the camera head MAC address from the MAC address field drop-down menu. Please note that MAC addresses for all camera heads on the same network appear in the MAC address field drop-down menu. Enter the IP address in the IP address field. Avoid overlapping with other devices in the same network of the control unit. By clicking the [Set] button, camera communication settings are written to the control unit.

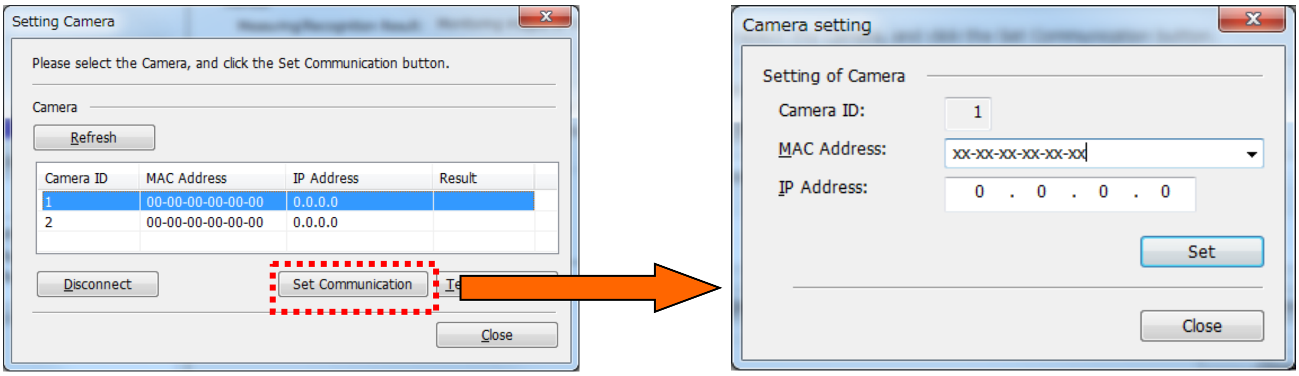


Fig. 7-24 Camera communication settings

Connection test

By selecting the camera for which communication settings were specified and then clicking the [Test Connection] button, a connection test is performed for the selected camera. If the connection test result is OK, close the Camera settings screen. If the test fails, check the camera communication settings.

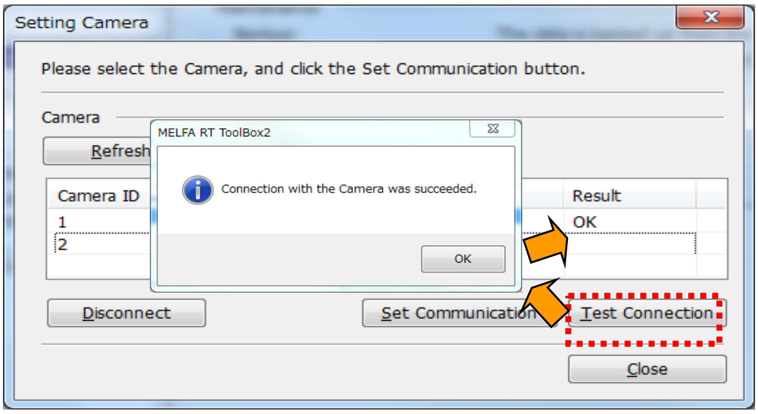


Fig. 7-25 Camera connection test

Circuit disconnection

If disconnecting the circuit for cameras for which communication settings are completed, select the camera from the list, and then click the [Disconnect circuit] button.

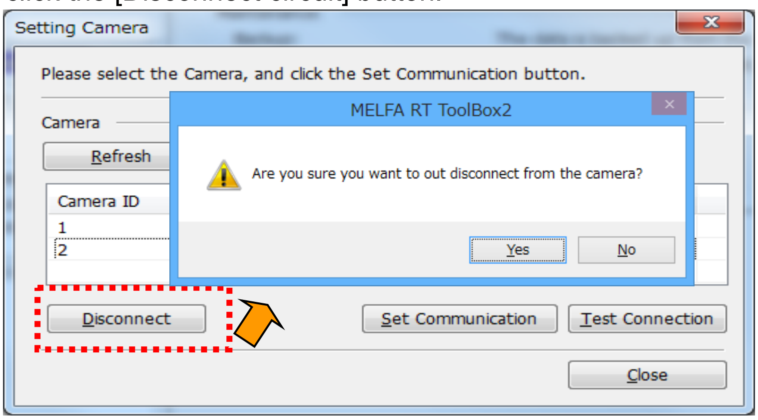


Fig. 7-26 Camera circuit disconnection

7.7.2. Robot settings

◇◆◇Robot settings◇◆◇

If performing a measurement or recognition check only and no picking work, robot settings are not required.

Robot setting screen display

This screen is used to specify robot communication settings. By clicking [Startup] - [1. Connection Setup] - [1-2 Robot setting] in the guidance menu at the MELFA-3D Vision setting screen, a Robot settings screen appears. By clicking the [Refresh] button, the latest information from the control unit is acquired.

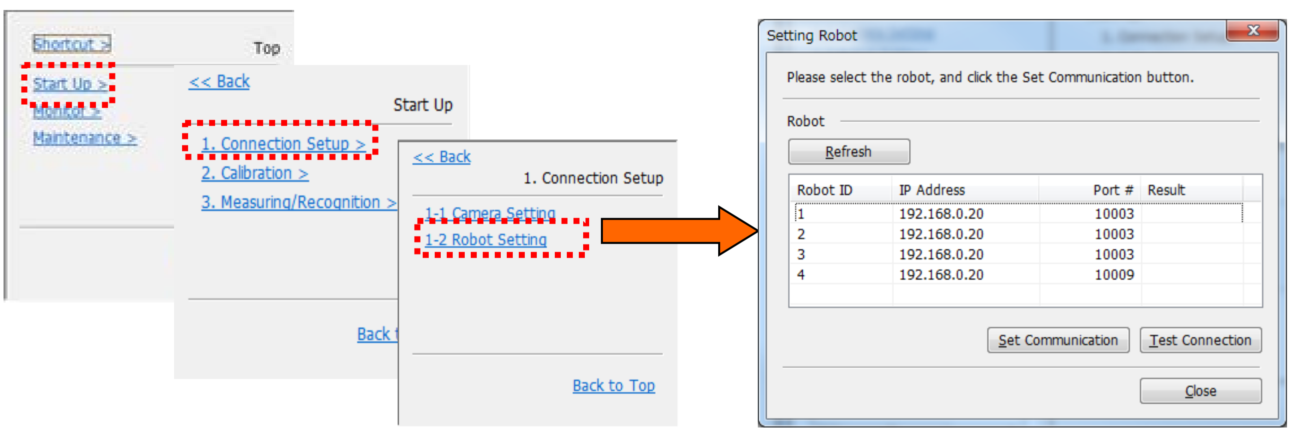


Fig. 7-27 Robot settings

Robot communication settings
Up to four robots can be connected to a single control unit. The four robots are identified by their robot ID. By selecting the robot ID for the robot to be registered and then clicking the [Set Communication] button, a Robot communication settings screen appears. Enter the IP address set for the robot in the IP address field. Enter the port No. to be used in the Port No. field Note 1. By clicking the [Set] button, robot communication settings are written to the control unit.

◇◆◇Port Nos.◇◆◇
Select the port No. to be set from 10001 to 10009. When doing so, ensure that the selected port is not used in the Ethernet settings in the robot parameters.

Note 1: The port No. used must be set in one of the robot parameter NETPORT elements, and not be used for communication for any other devices. (See Fig. 7-3.)

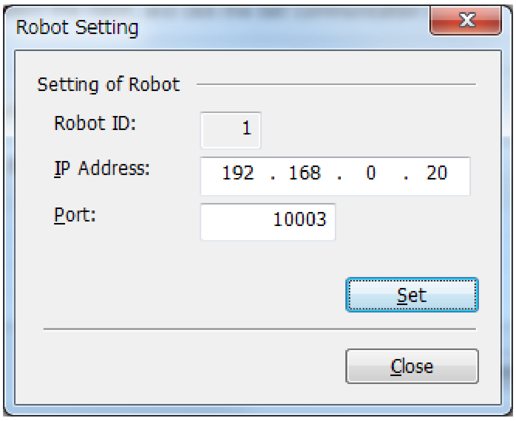


Fig. 7-28 Robot communication settings

Connection test
By selecting the robot for which communication settings were specified and then clicking the [Test Connection] button, a connection test is performed for the robot. If the connection test result is OK, close the Robot settings screen. If the test fails, check the robot communication settings.

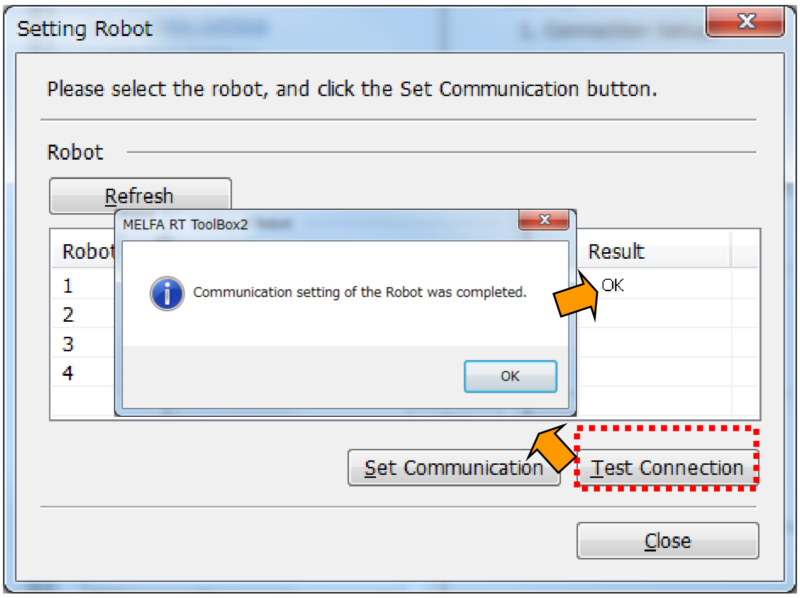


Fig. 7-29 Robot connection test

Ready signal settings

Once the Ready signal is set, a signal indicating that the control unit is running can be output from the specified robot. Using 8 bits from the specified signal, it counts in 1-second intervals (0 to 255).
It is used to monitor the status of the controller unit (completion of startup, end, etc.) from other external devices.

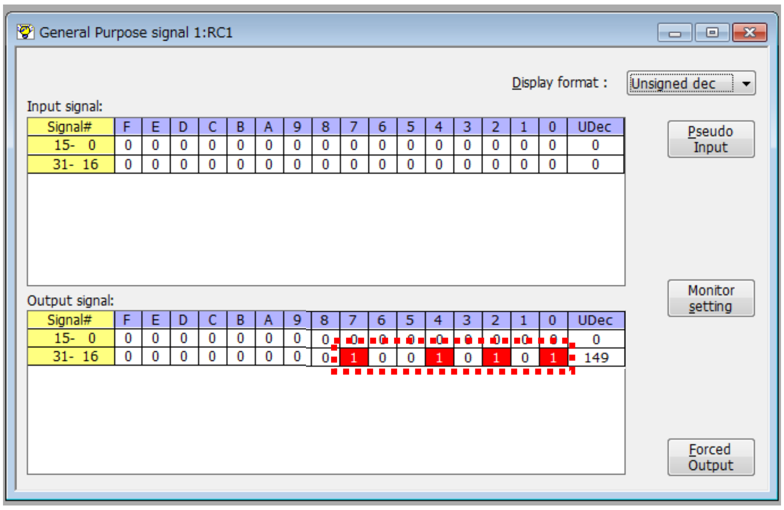


Fig. 7-30 Example of using the Ready signal

When specifying the Ready signal, click [Set ready signal] in the context menu, which appears by right-clicking the subject robot on the [Robot] tab from the property monitor.
On the displayed settings screen, enter the first signal number allocated to the Ready signal. Enter "-1" in order to turn off the Ready signal. Clicking [Set] enters the settings of the Ready signal in the controller unit.

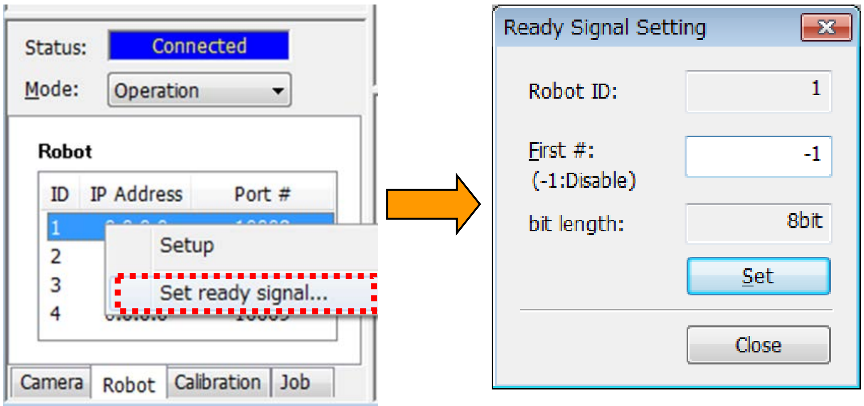


Fig. 7-31 Ready signal settings screen

◇◆◇When error4320 occurs◇◆◇
When error 4320 occurs with a robot controller after the Ready signal setting, refer to No.9 of 10.3 Q&A.

7.8. Calibration

Creating new calibration data

Perform calibration of the camera. By clicking [Startup] - [2. Calibration] - [2-1 Create Data] in the guidance menu at the MELFA-3D Vision setting screen, new calibration data is created and a Calibration screen appears.

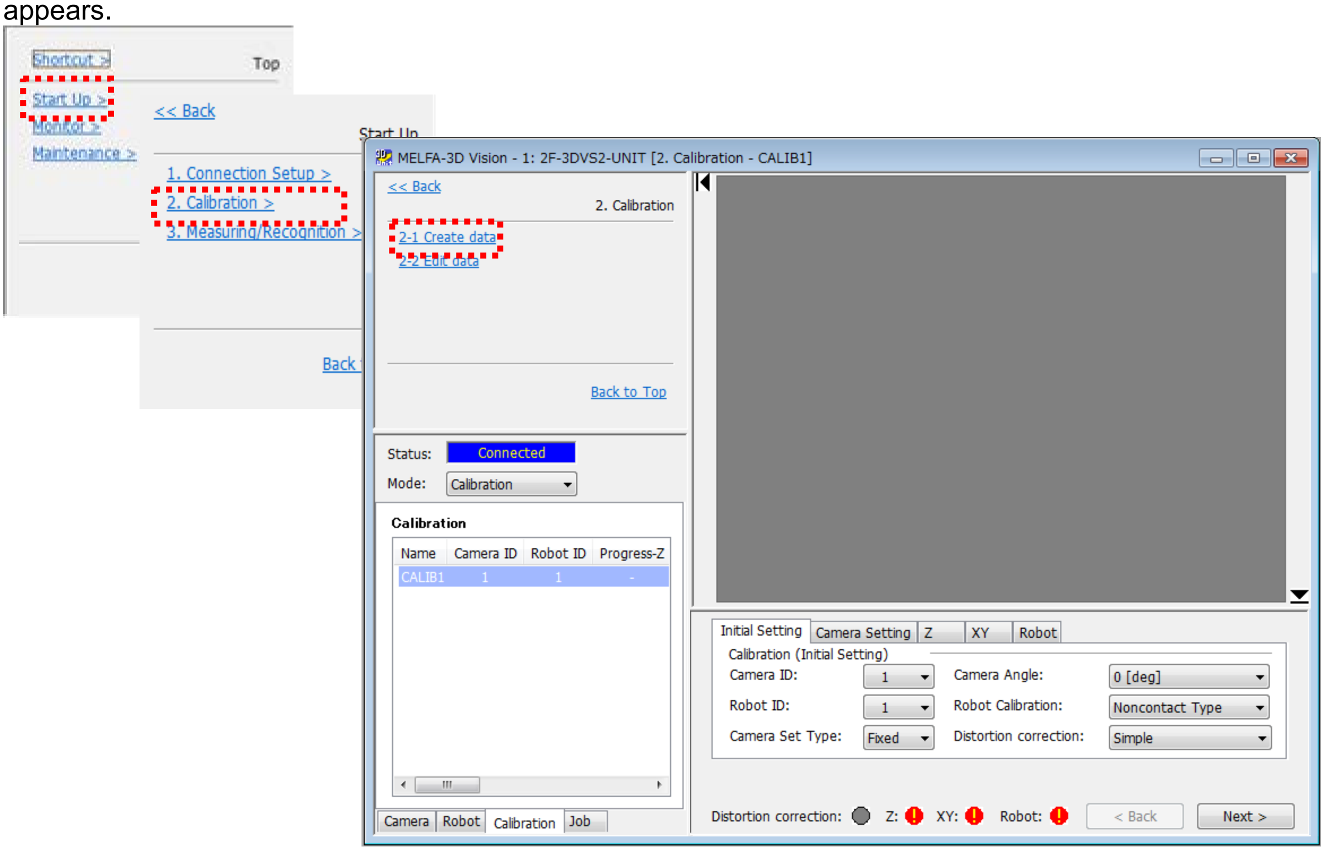


Fig. 7-32 Calibration

◇◆◇Creating new calibration data◇◆◇
New calibration data can also be created from the context menu that appears when right-clicking the "Calibration" tab in the Properties window.

Editing existing calibration data

For editing the existing calibration data, by clicking [Startup] - [2. Calibration] - [2-2 Edit Data] in the guidance menu, a Calibration data selection screen appears. Select the calibration data to be edited and click the [Select] button.

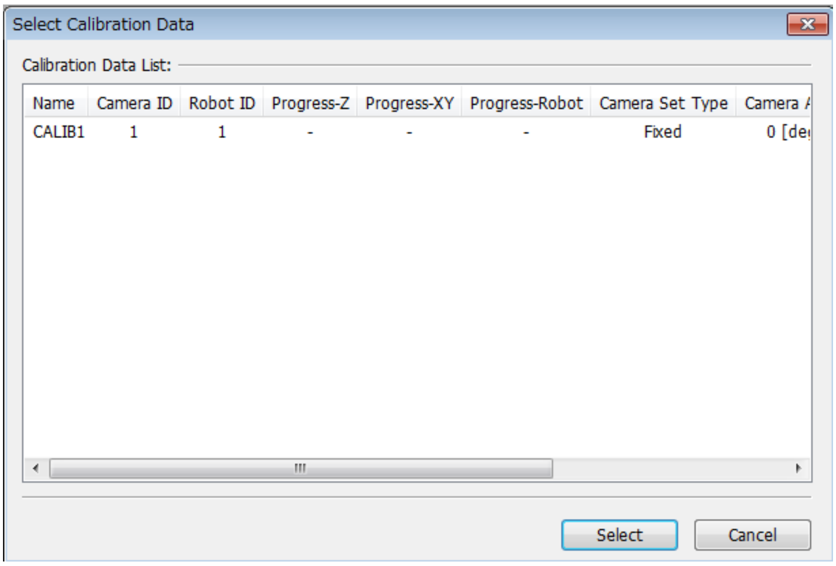


Fig. 7-33 Selection of calibration data

Changing the calibration data name
For changing the calibration data name, select the Calibration tab in the Properties window, right-click the applicable calibration data name to display the context menu, and then click [Rename] in the context menu to change the name.

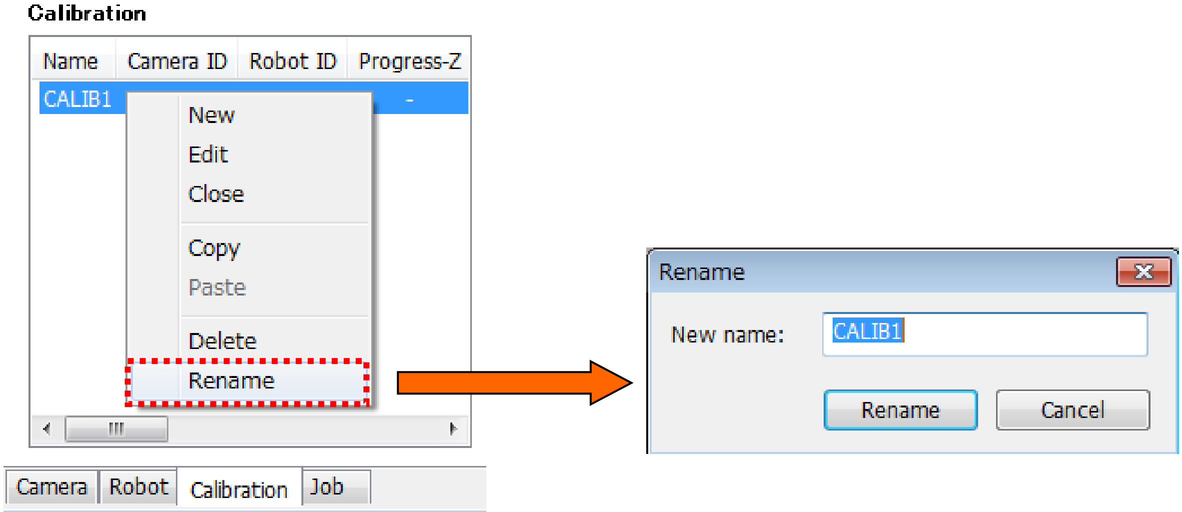


Fig. 7-34 Changing the calibration data name

Deleting calibration data
For deleting the calibration data, click [Delete] in the context menu. However, calibration data that is being edited cannot be deleted. To close the Edit screen, click [MELFA-3D Vision] - [Close calibration data] on the menu bar.

7.8.1. Initial settings

In the initial settings, select the following items according to the equipment configuration. When selection is completed, click the [Next] button.

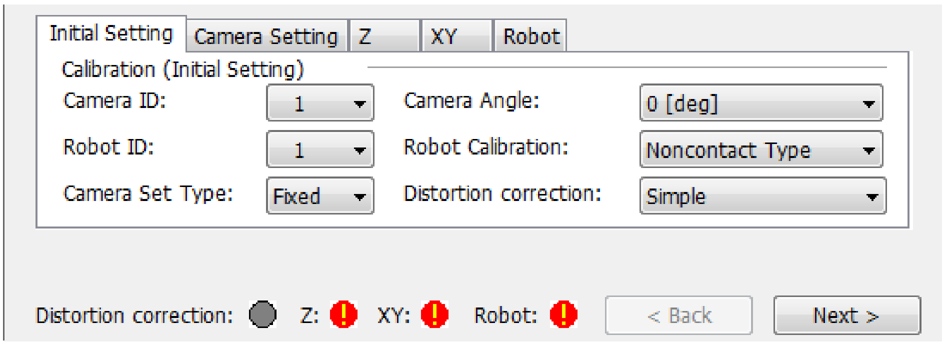


Fig. 7-35 Calibration (initial settings)

Table 7-3 Instructions for calibration (initial setting) items

Item	Description
Camera ID	Camera ID being used (see 7.7.1)
Robot ID	Robot ID being used (see 7.7.2)
Camera Set Type	Hand eye / Fixed camera
Camera Angle	0 degrees : Normal position 90 degrees : Extended field of view option being used
Robot Calibration	Non-contact: This method for vertical 6-axis robot is a non-contact type which recognizes a target mark at different robot poses. Contact: This method for vertical 6-axis robot and horizontal 4-axis robot is a contact type which points out 5 mark positions and recognized them.(Fixed camera use only) * Vertical 5-axis robot with a fixed downward fifth axis can use the contact type method.
Distortion correction	Simplified method: Correct lens distortion easily. Detailed method: Correct lens distortion using a checkerboard. * Select the simplified method for normal use. Select the detailed method when the extended field of vision option is used or high accuracy is requested.

7.8.2. Camera settings

The camera head projector irradiation range and focus, camera focus and aperture adjustments, and parameter settings are specified in the camera settings.

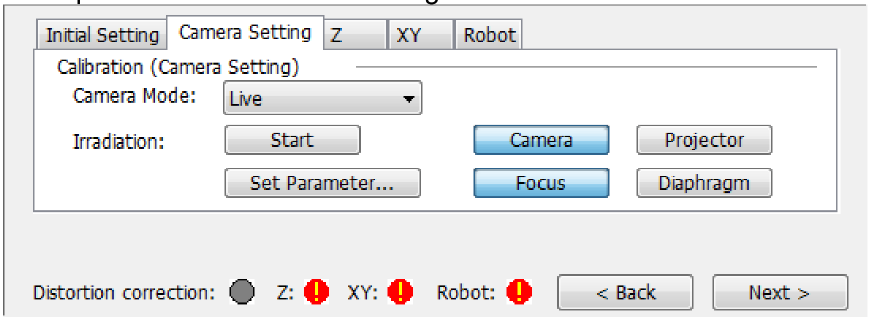


Fig. 7-36 Calibration (camera settings)

◇◆◇Before adjusting the camera aperture and focus◇◆◇
Ensure that the lens is secured properly to the lens mount. If insufficiently secured, the lens may loosen when the ring is rotated to adjust the aperture and focus.

7.8.2.1. Temporary projector adjustment

<u>Irradiation range adjustment</u>

Raise the Z calibration plate (2F-3DVS2-Z-S/M/L) to the estimated workpiece stacking height with a raising block (2F-3DVS2-STAND), etc.

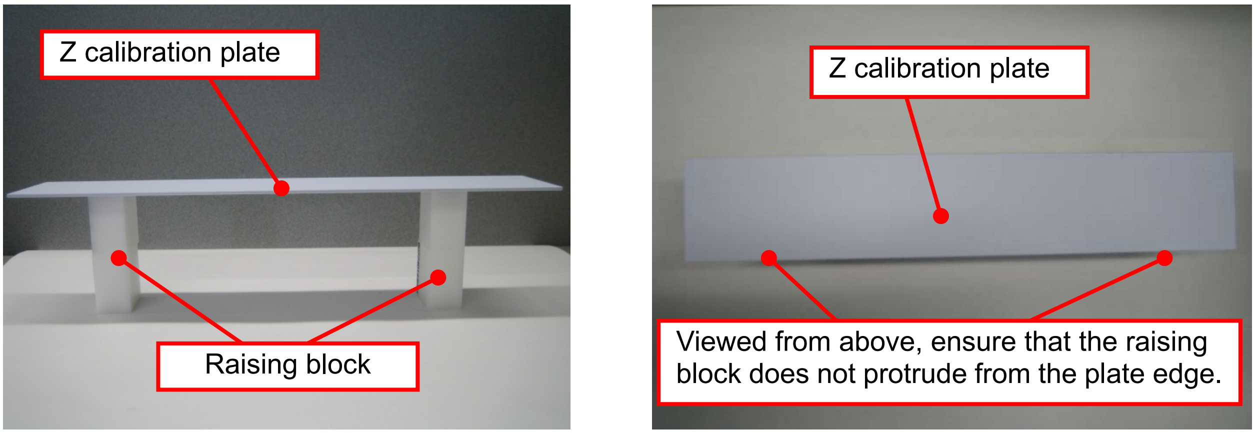


Fig. 7-37 Example of raised Z calibration plate

Set the camera mode to live image, and position the Z calibration plate so that it aligns with the light blue lines displayed on the image monitor. If it does not align, select another Z calibration plate that aligns with the light blue lines as best as possible, and position it so that the red line in the center of the image monitor comes to the center of the Z calibration plate Note 1. When doing so, ensure that the edges of the Z calibration plate are not inside the camera field of view.

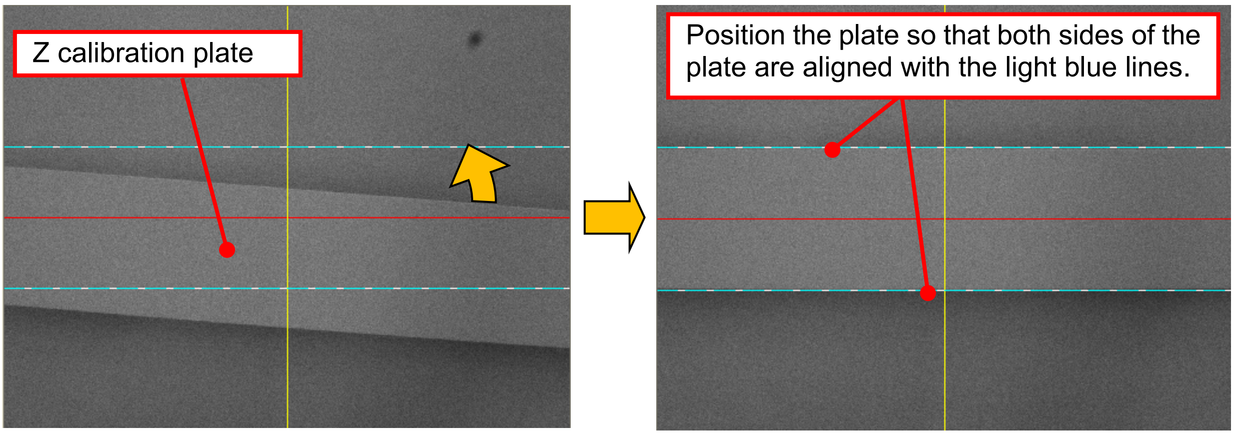
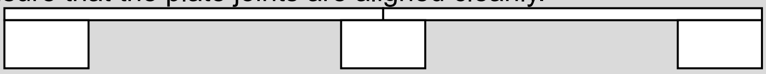


Fig. 7-38 Example of Z calibration plate alignment

◇◆◇Z calibration plate◇◆◇

- The plate is different on each side. Use with the matte surface facing up. If the glossy surface (indicating the model name) is used, the measurement test and Z calibration may fail.
- Both 4F-3DVS2-Z-M and 4F-3DVS2-Z-L are provided in two pieces. Joint two pieces of Z calibration plates together. Ensure that the plate joints are aligned cleanly.



- If more raising blocks (2F-3DVS2-STAND) are required, prepare the additional block(s).

By clicking the pattern irradiation [Start] button, pattern irradiation from the projector is started. Within the irradiated pattern, the range shown in Fig. 7-39 is the measurable area. To ensure that this measurable area comes to the center, adjust the projector angle while watching the image monitor. When doing so, temporarily adjust the camera aperture and focus so that the pattern irradiation visibly appears in the image monitor.

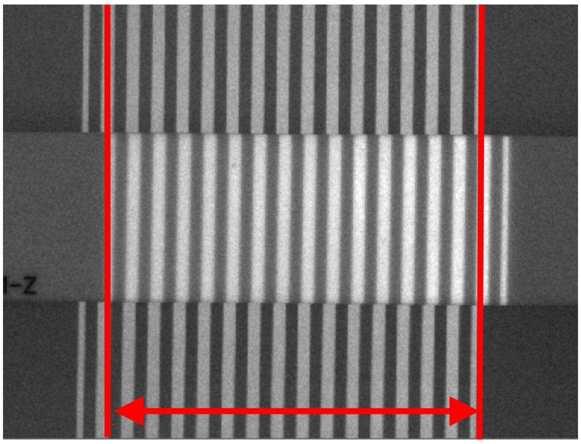


Fig. 7-39 Measurable area

Note 1: Keep it in place until the Z calibration is completed.

<u>Temporary focus adjustment</u>

By changing to the projector mode by selecting [Projector], only a specific irradiation pattern is monitored by the screen. Projector mode is reset by selecting [Camera].

Turning the projector focus adjustment knob (refer to Fig. 7-41), focus on the patterned irradiation on the monitor screen to bring each pattern on the plate for Z calibration and on the measurement stand into focus in a balanced manner and at the same level.

If the adjustment is believed insufficient following the above mentioned procedure, visually confirm that you can clearly see the burr (because of the characteristics of the projector) at the actual irradiated pattern corner (as an auxiliary means).

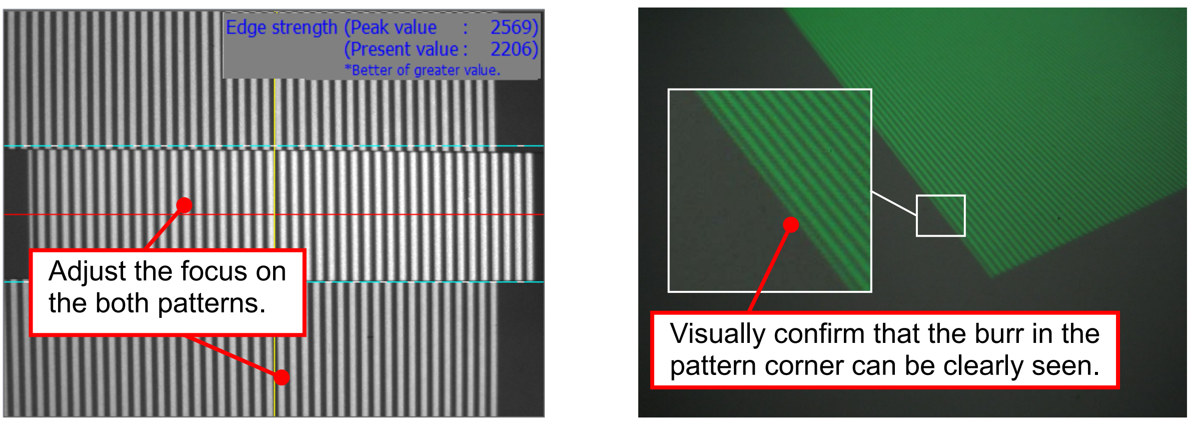


Fig. 7-40 Temporary projector focus adjustment

Upon completing the focus adjustment, turn the focus fixing screw (refer to Fig. 7-41) and fix the focus of the projector. [Note 1]

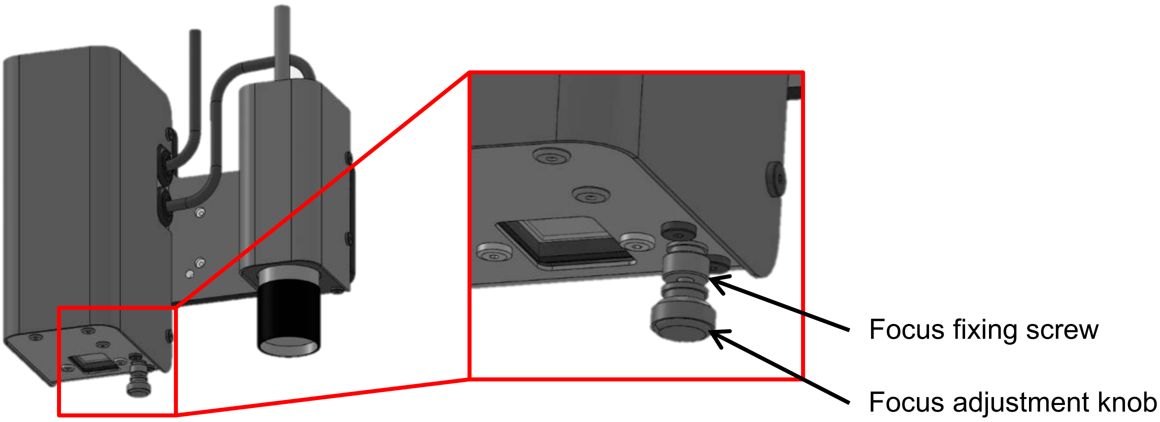


Fig. 7-41 Focus adjustment knob and focus fixing screw

Note 1: Note that the focus adjustment knob is not turning when turning the focus fixing screw.

7.8.2.2. Temporary camera adjustments

Temporary focus adjustment

Select [Camera] and reset the projector mode.

Place a patterned paper (refer to Chapter 11.1), etc. on the plate for Z calibration and on the measurement stand, and select [Focus].

While looking at the picture displayed on the screen monitor and the value of the edge strength, adjust the focus to bring each pattern on the plate for Z calibration and on the measurement stand into focus in a balanced manner and at the same level.

The bigger the edge strength value, the clearer the difference between the light and shade will become, bringing it into focus. As the greatest value of the edge strength since the start of adjustment will be displayed as the peak value, this function can be used as a reference to adjust the focus.

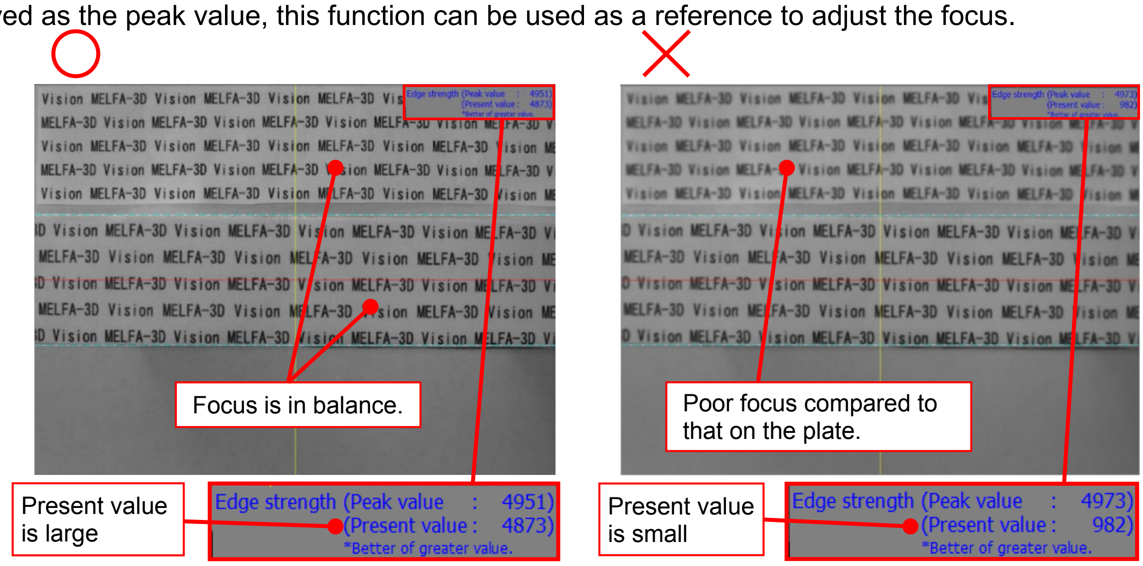


Fig. 7-42 Temporary camera focus adjustment example

Temporary aperture adjustment

Go to projector mode and select [Diaphragm].

While looking at the picture displayed on the screen monitor and the following information, adjust the diaphragm of camera so that the light and shade of the pattern becomes clear with regular intervals.

- When the distribution of the histogram displayed in the upper left deviates to the edge of either the right or left, this means there is deflection in the light and shade of the pattern. Adjust it such that two peaks are created without deviating to the edge.
- Adjust it such that the saturated brightness level is the small value. The recommended value is less than 10%.

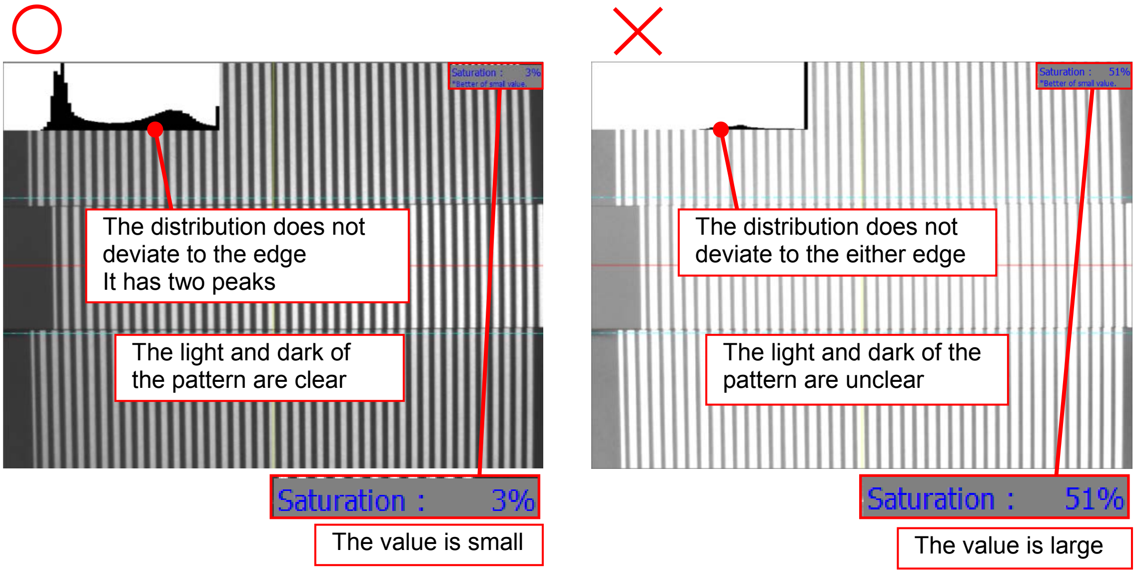


Fig. 7-43 Temporary adjustment example for the camera diaphragm

7.8.2.3. Measurement test

A measurement test can be performed by the [Camera Setting] mode to the pattern image and clicking the [Test] button. If the display is set to "All", the pattern image and three camera images appear on the image monitor when the measurement test is performed.

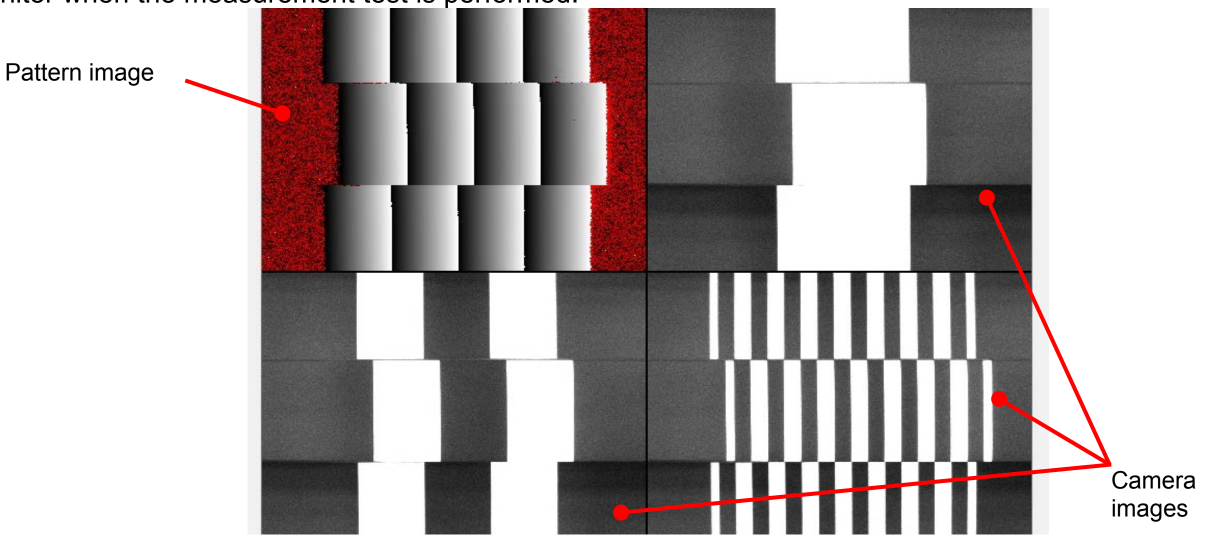


Fig. 7-44 Measurement test result example

Ensure that there are no red areas in the striped part of the pattern image. Red areas indicate that range measurement has been unsuccessful. If red areas exist, readjust the camera head using the following procedure. Please note that red areas do not represent a problem in areas <i> and <ii> in Fig. 7-45.

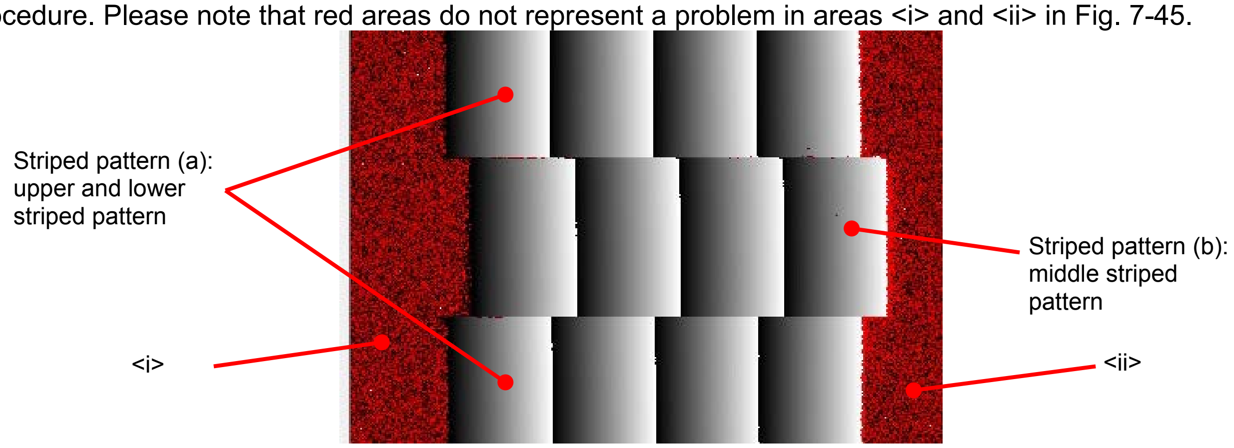


Fig. 7-45 Pattern image (successful example)

<u>If red areas appear in both striped patterns (a) and (b)</u>

Perform readjustment using the following procedure.

1. The **camera aperture** may be poorly adjusted. Change the camera mode to the live image, perform the pattern irradiation, readjust the aperture so that pattern has a **distinct difference** between bright and dark with **equal intervals**, and then perform a measurement test again.
2. If no improvement is observed even after performing step 1, the **camera** may be out of **focus**. Change the camera mode to the live image, readjust the focus until a good balance is obtained between the patterns on the Z calibration plate and the measurement stand, and then perform a measurement test again.
3. If no improvement is observed even after performing steps 1 and 2, the **projector** may be out of **focus**. Change the camera mode to the live image, perform the pattern irradiation, readjust the projector focus until a good balance is obtained between the patterns on the Z calibration plate and the measurement stand, and then perform a measurement test again.

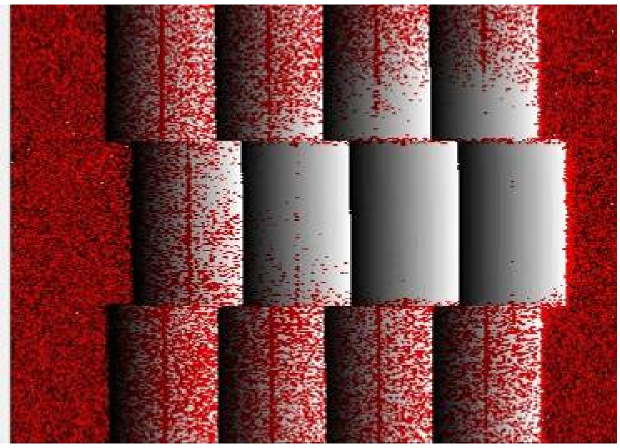


Fig. 7-46 Pattern image (unsuccessful example 1)

If red areas appear in striped pattern (a) only

Perform readjustment using the following procedure.

1. The **camera** may be poorly focused on the measurement stand. Change the camera mode to the live image, readjust until the measurement stand is in focus, and then perform a measurement test again.
2. If no improvement is observed even after performing step 1, the **projector** may be poorly focused on the measurement stand. Change the camera mode to the live image, perform the pattern irradiation, readjust the focus until the pattern on the measurement stand is in focus, and then perform a measurement test again.

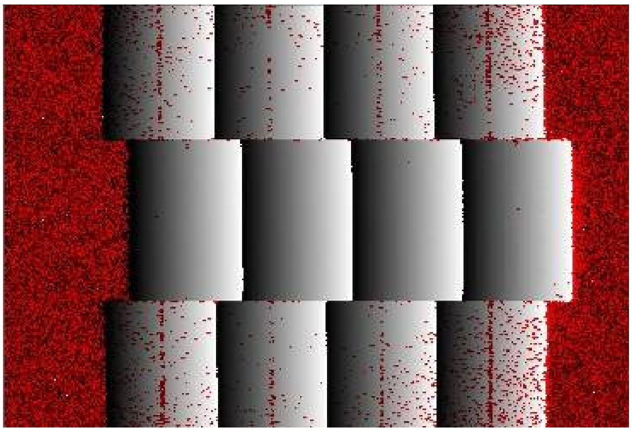


Fig. 7-47 Pattern image (unsuccessful example 2)

If red areas appear in striped pattern (b) only

Readjust using the following procedure.

1. The **camera** may be poorly focused on the pattern on the Z calibration plate. Change the camera mode to the live image, readjust so that the Z calibration plate is in focus, and then perform a measurement test again.
2. If no improvement is observed even after performing step 1, the **projector** may be poorly focused on the pattern on the Z calibration plate. Change the camera mode to the live image, perform the pattern irradiation, readjust the focus so that the pattern on the Z calibration plate is in focus, and then perform a measurement test again.

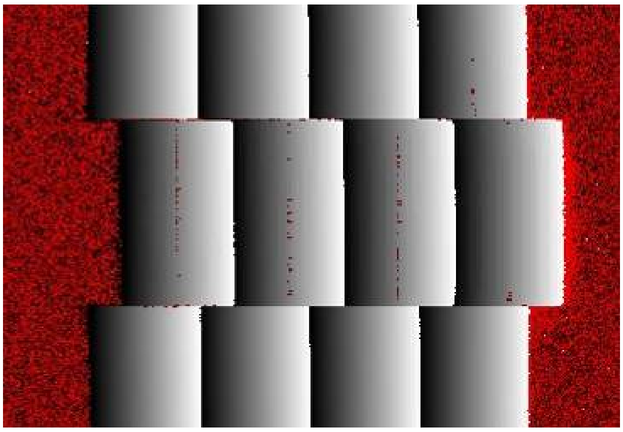


Fig. 7-48 Pattern image (unsuccessful example 3)

If there are no longer any red areas on the striped pattern, click the [Next] button to proceed to the Z calibration.

7.8.2.4. Parameter settings

By clicking the [Set Parameter] button in the Camera settings screen, the Camera parameter list screen appears. By clicking the parameter for which the value is to be changed in the parameter list and then clicking the [Change] button, the Camera parameter settings screen appears. By changing a value and clicking the [Set] button, the Camera parameter settings screen closes and returns to the Camera parameter list screen. At this point, the parameter has not yet been set in the control unit. By clicking the [Set] button in the Camera parameter list screen, the changed parameter value is set in the control unit. If the result of workpiece measurement described in 7.9.1.2 is not satisfactory, measurement results can be improved by changing the camera parameters.

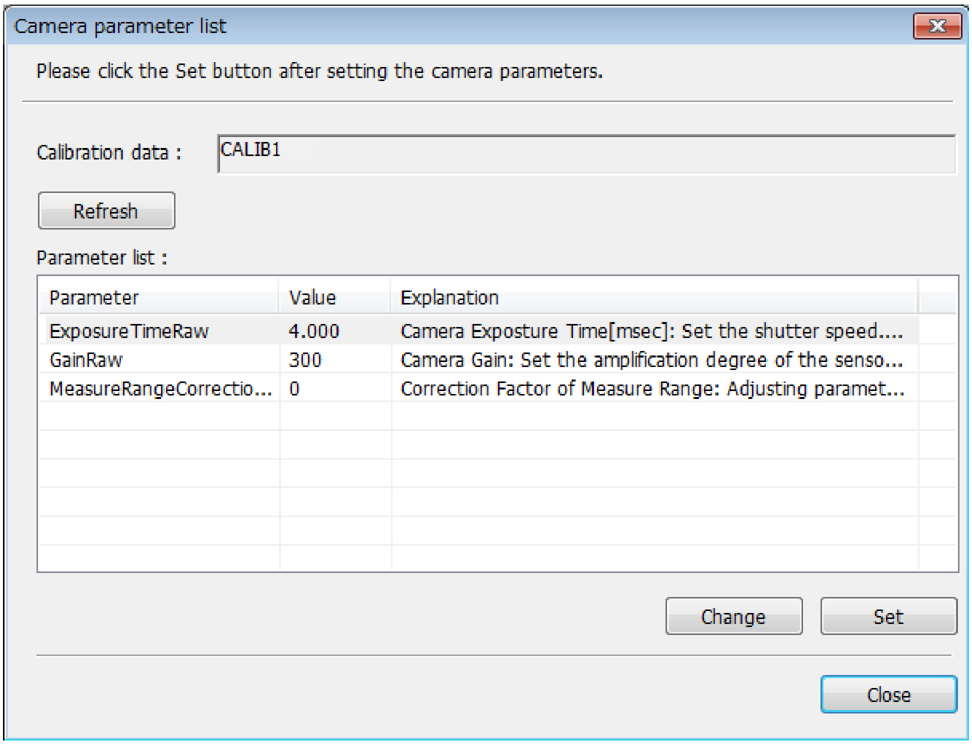


Fig. 7-49 Camera parameter list

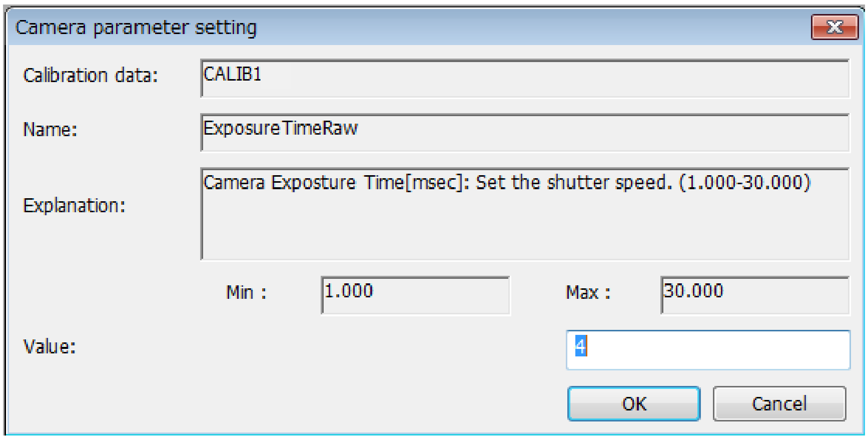


Fig. 7-50 Camera parameter settings

Table 7-4: Camera parameter list

Parameter name	Unit	Description	Range	Default setting
ExposureTimeRaw	msec Note 1	Camera exposure time [msec]: Set the shutter speed.	1.000 to 30.000	4.000
GainRaw	-	Camera gain: Set the amplification degree of the sensor signal (Sensitivity).	300 to 850	300
MeasureRange CorrectionFactor	-	Correction Factor of Measure Range: Adjusting parameter of measurement range. This parameter changes the unmeasurable area.	-10 to +10	0

Note 1: For versions of MELFA-3D Vision under Ver.1.2, note that the unit is μsec.

◇◆◇Exposure time◇◆◇

If the measurement test is not satisfactory for black or dark objects, it may be possible to improve the result by increasing the exposure time.

◇◆◇ About unmeasurable area ◇◆◇

According to the work piece distance and the length between camera and projector, unmeasurable area may occur. This area can be seen as black band-like area spreading to same direction of the light pattern slit.

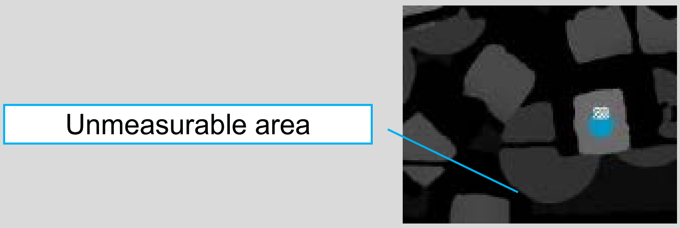
Because of the measurement principle, these areas always exist outside of measurement. But, sometimes this area can be seen in the measurement image around the boundary according to the setting.

When you see the unmeasurable area, please try to the following countermeasures.

(1) Adjust the degree of projector setting in order to make the light patterns inside of the field of camera view.

(2) Adjust the MeasureRangeCorrectionFactor parameter.

(3) Change the base plate and shorten the distance between camera and projector.



7.8.3. Distortion correction

To correct the distortion, a checkerboard is used to correct camera head lens distortion. This function can be used by setting [Distortion correction] from the Calibration setting under the initial settings to [Detail]. Further, use "Checkerboard_8x11.pdf" [Note 1] in the CD-ROM as a checkerboard.

Note 1: Data files are in "ENG\3DVS-Calibration_Marker_ENG\Checkerboard_8x11.pdf". In addition, use it by scaling depending on the usage environment (camera viewing field size).

Checkerboard settings

Clicking [Edit] on the distortion correction screen displays an edit screen for checkerboard. Input each value for the horizontal and vertical numbers of the cell of the checkerboard to be used and the length of each side per one cell. By clicking [Set], the setting values of checkerboard are reflected.

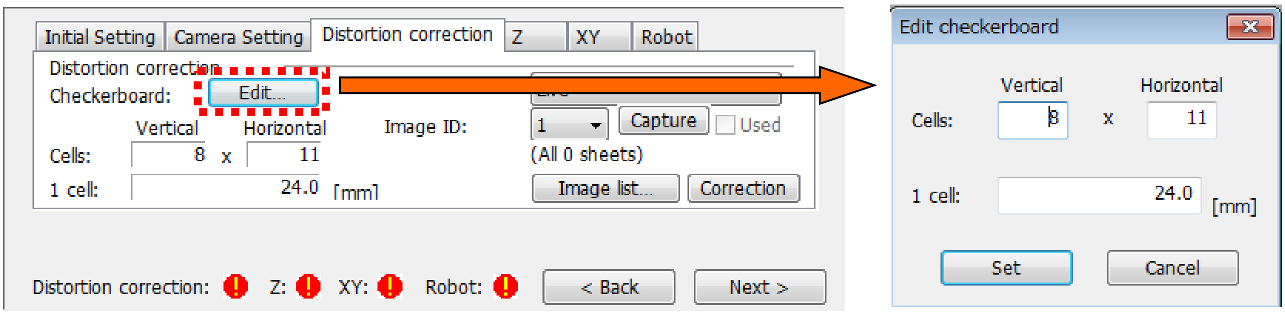


Fig. 7-51 Checkerboard settings

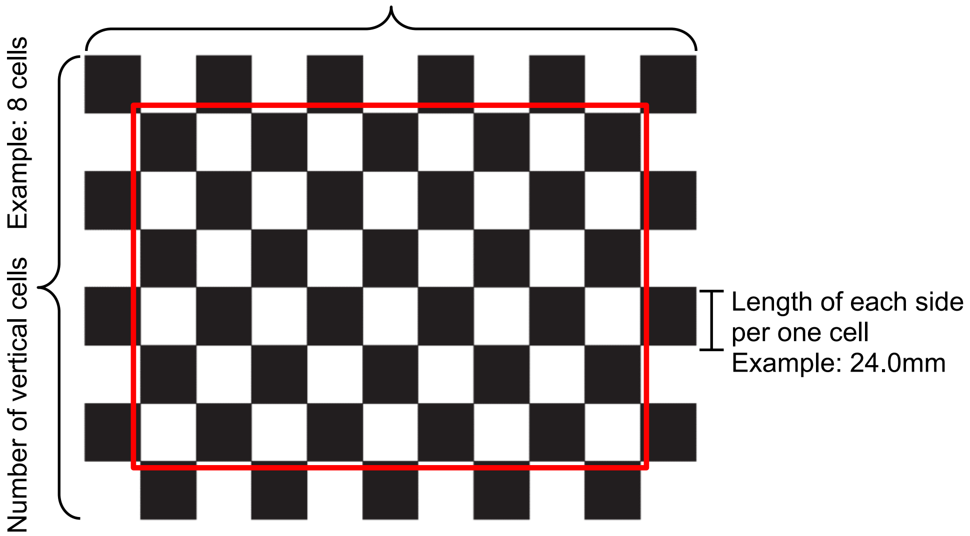


Fig. 7-52 Instructions for the parameters during setting of the checkerboard

Photographing images
Images can be photographed by selecting [Live] from the camera mode pull-down and clicking [Capture]. Up to 25 capture images can be registered. In addition, the image ID selected is the image registration number.

◇◆◇Photographing checkerboards◇◆◇
- Adjust the field of vision of the camera in such a way that the checkerboard is visible at around 80% of the size.
- Set up the checkerboard in such a way that the target subject within the red frame of Fig. 7-52 is included within the photographic image.
- Prevent the paper of the checkerboard from being warped when photographed. (You may place it on cardboard, etc.)
- Confirm that the camera is in focus.
- The target number of images to be used is at least 10 images.
- When a failure occurs in corner detection, adjust the exposure time of the camera setting, then enhance the contrast of the image.

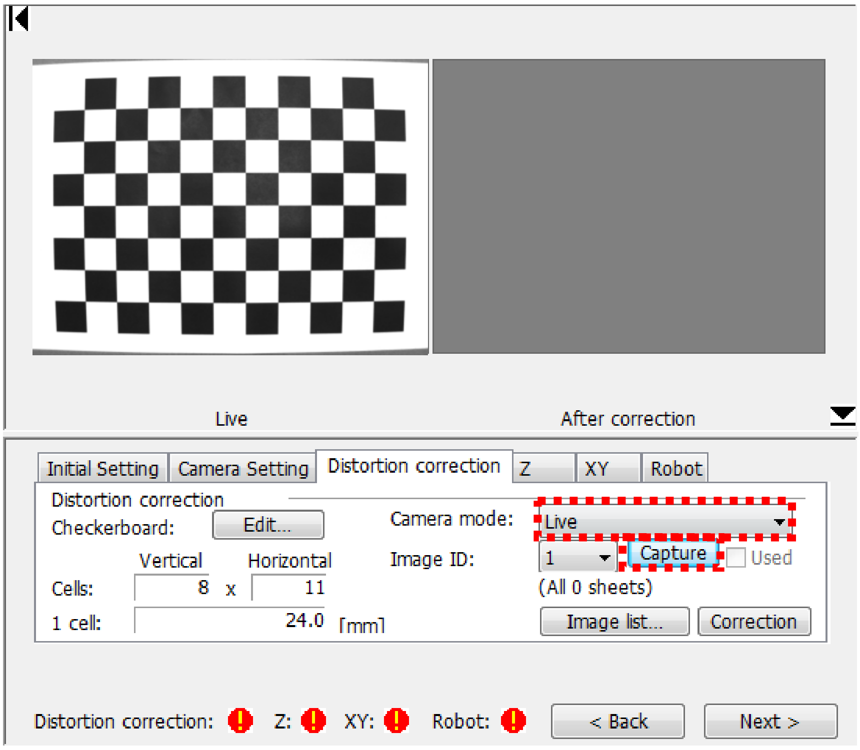


Fig. 7-53 Method of photographing images

Confirmation of capture images and selection of images to use for distortion correction

Capture images can be confirmed by selecting [Capture image] from the camera mode pull-down and selecting the image ID to be confirmed. In addition, by clicking [Used] check box, you can decide whether the image is used for distortion correction. Selected images will be used for distortion correction.

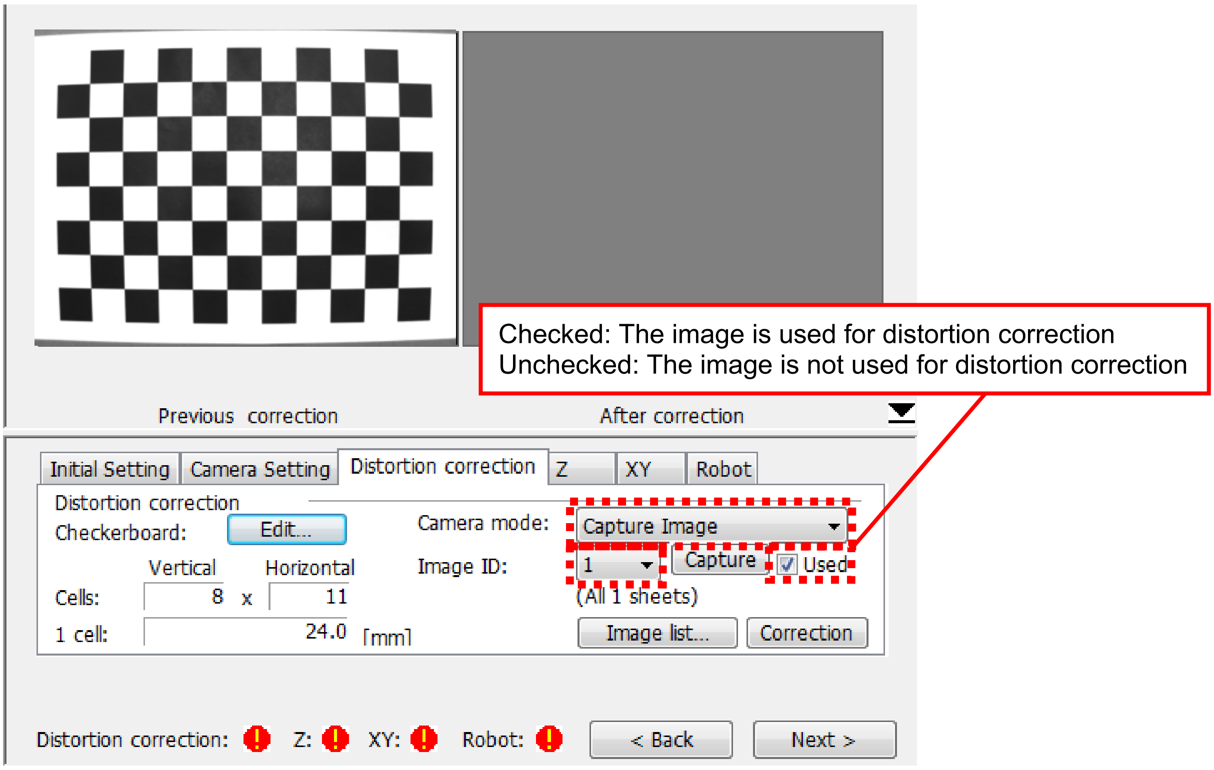


Fig. 7-54 Confirmation of the capture images and the selection method of images to use for distorted correction

Capture images from a list can be displayed by clicking [Image list] and the image can be enlarged by double-clicking the image. Selecting a check box means the image will be used for distortion correction. The processing time for the correction can be shortened by clearing the check boxes and reducing the image number of images to be used for distortion correction.

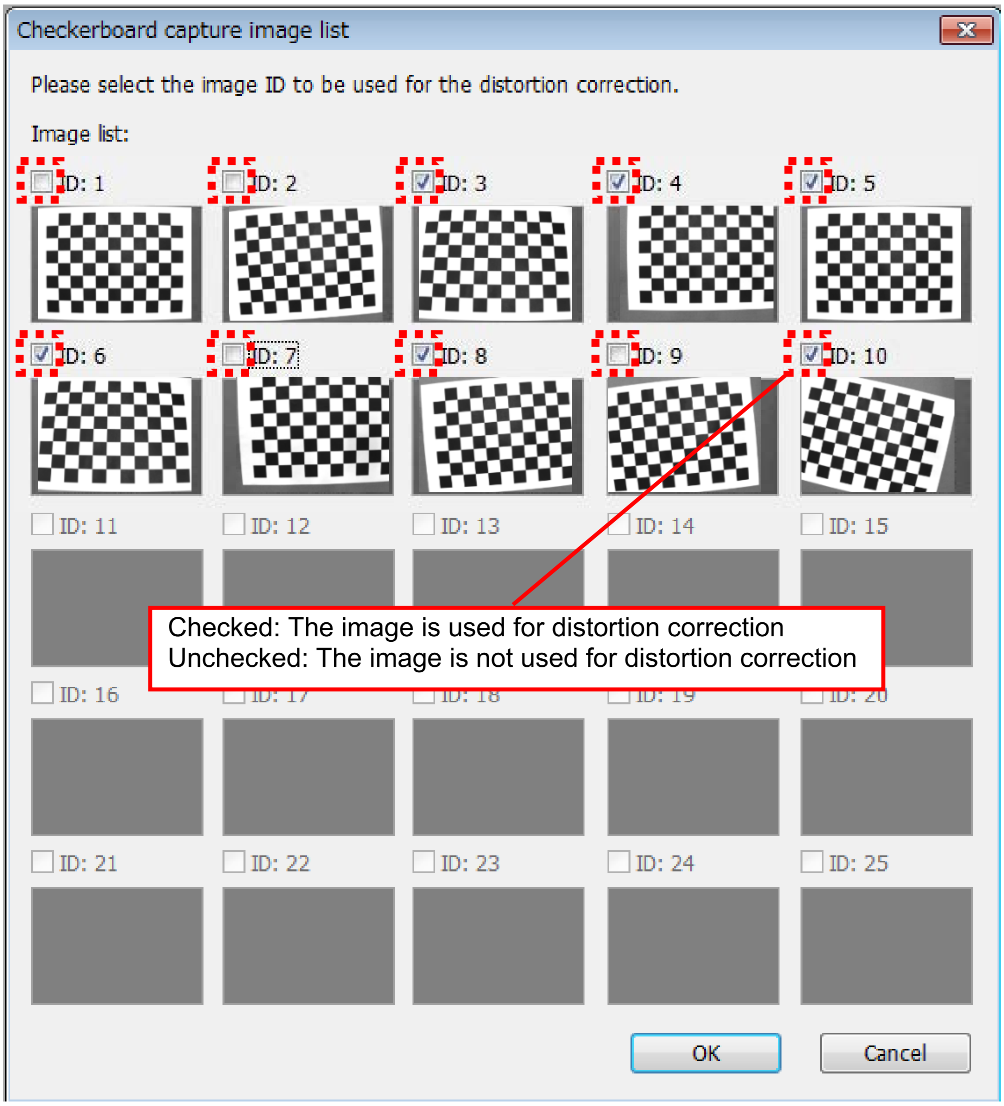


Fig. 7-55 Image list

Implementation of distortion correction

Implement distortion correction by clicking [Correction]. When the implementation is completed, the evaluation value of distortion correction will be displayed. Determine the completion of distortion correction for the camera lens based on the evaluation value. In addition, because the capture images before and after the correction can be displayed upon completing the distortion correction, the effect of the distortion correction can be confirmed from the image after the correction.

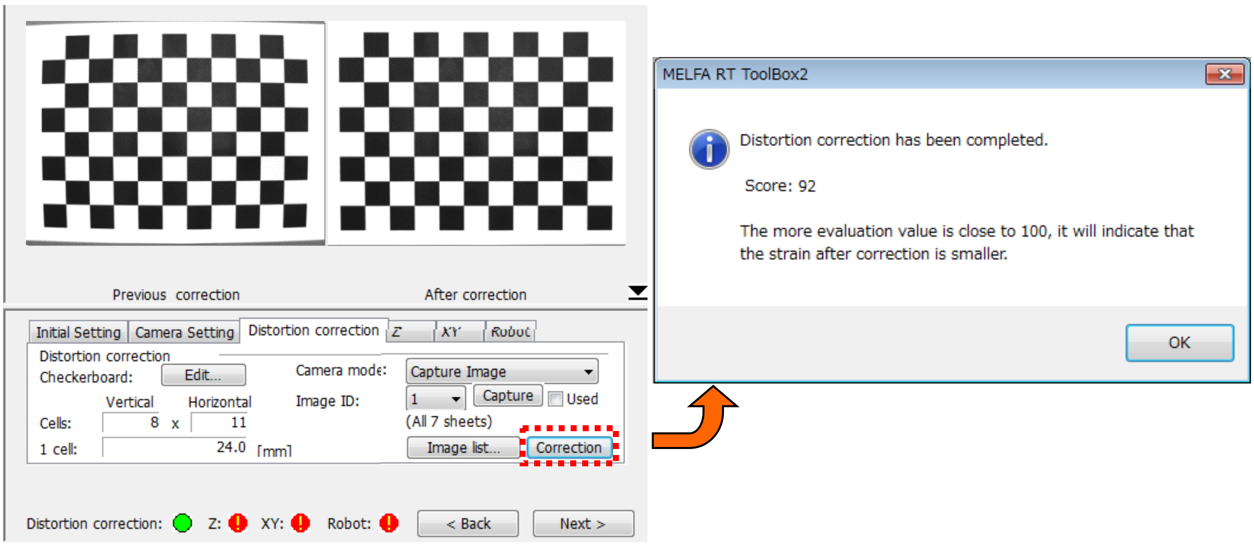


Fig. 7-56 Implementation method of distortion correction

◇◆◇Implementation of distortion correction◇◆◇

- When the evaluation value of distortion correction is low, increase the number of images used. Photograph the installed checkerboard from various angles (camera optical axes) (refer to Fig. 7-55). In addition, the target evaluation value of distortion correction should be 90 or more.
- When a failure occurs in corner detection during correction, do not use the target image for correction, or photograph it once again.

When the distortion correction is completed, go to Z Calibration by clicking [Next].

7.8.4. Z calibration

In the Z calibration, perform calibration of the camera head in the lens vertical direction. Use the Z calibration plate (2F-3DVS2-Z-S/M/L) placed in the camera settings.

Entering the distance to the measurement stand and the height of the Z calibration plate

Enter the distance from the camera head lens mounting base (camera front end flange surface) to the measurement stand in the "Distance to measurement stand" field, and enter the Z calibration plate height [Note 1] in the "Block height" field. Inaccuracy will affect the accuracy of the system when being used. Enter the values within the margin of ±1 [mm] or less. Regarding the flange face at the anterior end of the camera, refer to Fig. 3-9.

Note 1: The height of the plate is targeted at the upper limit height degree where usage (measurement) is expected. However, because the measurement accuracy deteriorates when it is out of focus, the plate height needs to be adjusted within the range in focus.

◇◆◇Camera head posture when performing Z calibration◇◆◇

When using the hand eye, move the robot so that the camera front end flange surface is parallel (±0.5 [deg.] or less) to the measurement stand. And when using the fixed camera, ensure that the camera head attachment posture is parallel to the measurement stand in the same manner. Perform adjustment using a digital spirit level. Not doing so will affect the measurement accuracy when the system is used.

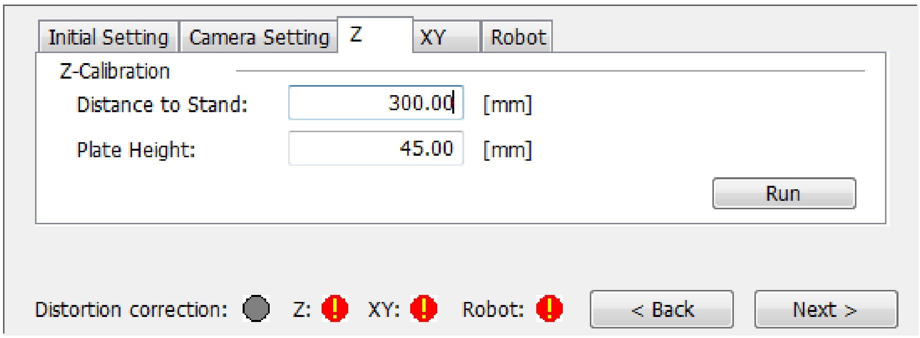


Fig. 7-57 Z calibration

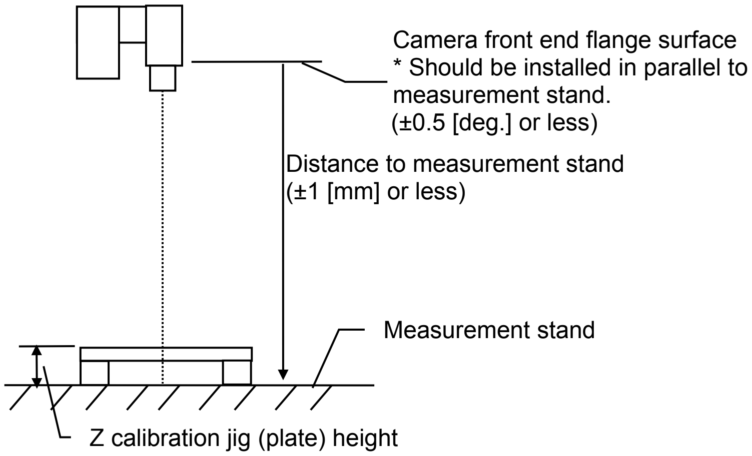


Fig. 7-58 Z calibration parameter description

<u>Performing Z calibration</u>
Click the [Run] button to perform the Z calibration. The pattern image and the range image are displayed on the image monitor. By performing the Z calibration, the red circle next to "Z:" in the setting/operation field changes to a green circle. An example of successful Z calibration is shown in Fig. 7-59

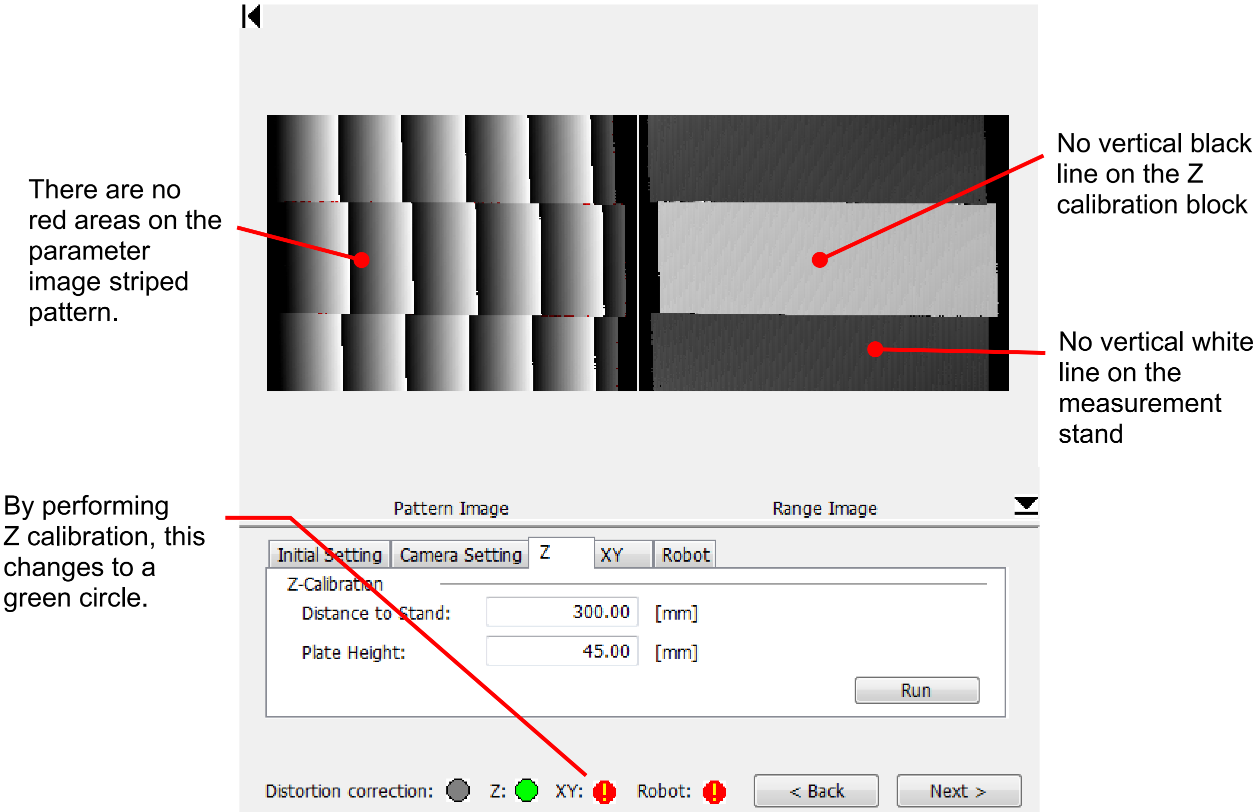


Fig. 7-59 Successful example of Z calibration

Check the following if the displayed image is not as shown in Fig. 7-59.

Table 7-5: Check items when Z calibration unsuccessful

No.	Check item	Remedy
1	Are the values entered for the distance to the measurement stand and the plate height correct?	Ensure that the actual values are the same as the entered values.
2	Is there any ambient light [Note 1]?	Block any ambient light.
3	Is the glossy surface of the Z calibration plate facing up?	Use with the matte surface facing up.
4	Are there any red areas on the pattern image striped pattern?	If so, return to "7.8.2.3 Measurement test" and readjust the focus and aperture again.
5	Are there any vertical black lines on the Z calibration plate in the range image [Note 2]?	When any black lines exist, return to "7.8.2.3 Measurement test" and readjust the focus and aperture again to ensure that there are no red areas on the parameter image striped pattern.

Note 1: General lighting (fluorescent light, etc.) is also ambient lighting.
Note 2: Vertical black lines show the area for which distance could not be recognized. If vertical lines are present at the edge and they lie outside the area used for actual measurement, readjustment is not necessary.

When the Z calibration is completed, click the [Next] button to proceed to the XY calibration.

7.8.5. XY calibration

In the XY calibration, use an XY calibration plate (2F-3DVS2-XY, 2F-3DVS2-XYR-M/L), raised using a raising block (2F-3DVS2-STAND), and perform calibration of the camera head in the lens horizontal direction.

◇◆◇XY calibration plate◇◆◇
- 2F-3DVS2-XY is different on each side. Use with the matte surface facing up. If the glossy surface (indicating the model name) is used, the measurement test and the XY calibration may fail.
- 2F-3DVS2-XYR-M/L also serves as the robot calibration plate. Use with the plain surface facing up. If the robot calibration surface is used, the XY calibration may fail.
- There are two sizes of robot calibration plate (2F-3DVS2-XYR-M/L). Use the larger plate as far as the plate fits within the green frame displayed on the image monitor.

<u>Entering the size and height of plate</u>
The value entered for Z calibration will still remain as the distance to the measurement stand. There is no need to change it. For the plate size, enter the length of the square side of the XY calibration plate viewed from above.
For the plate height, enter the height of the raised XY calibration plate. Raise the plate to the height corresponding to the half of the height to which the Z calibration plate is raised.

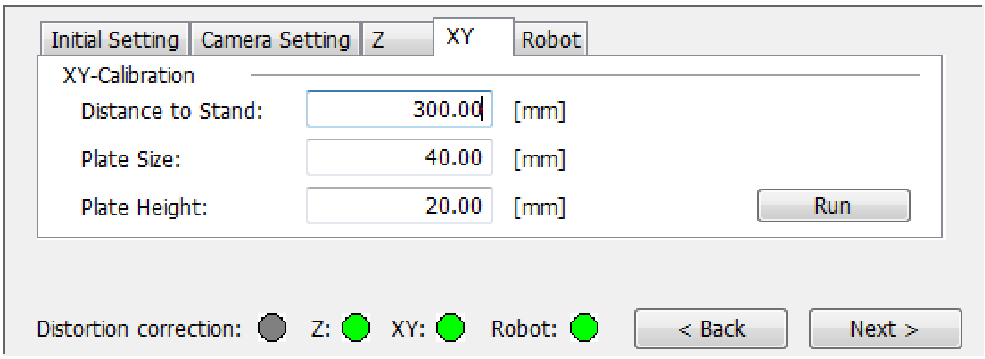
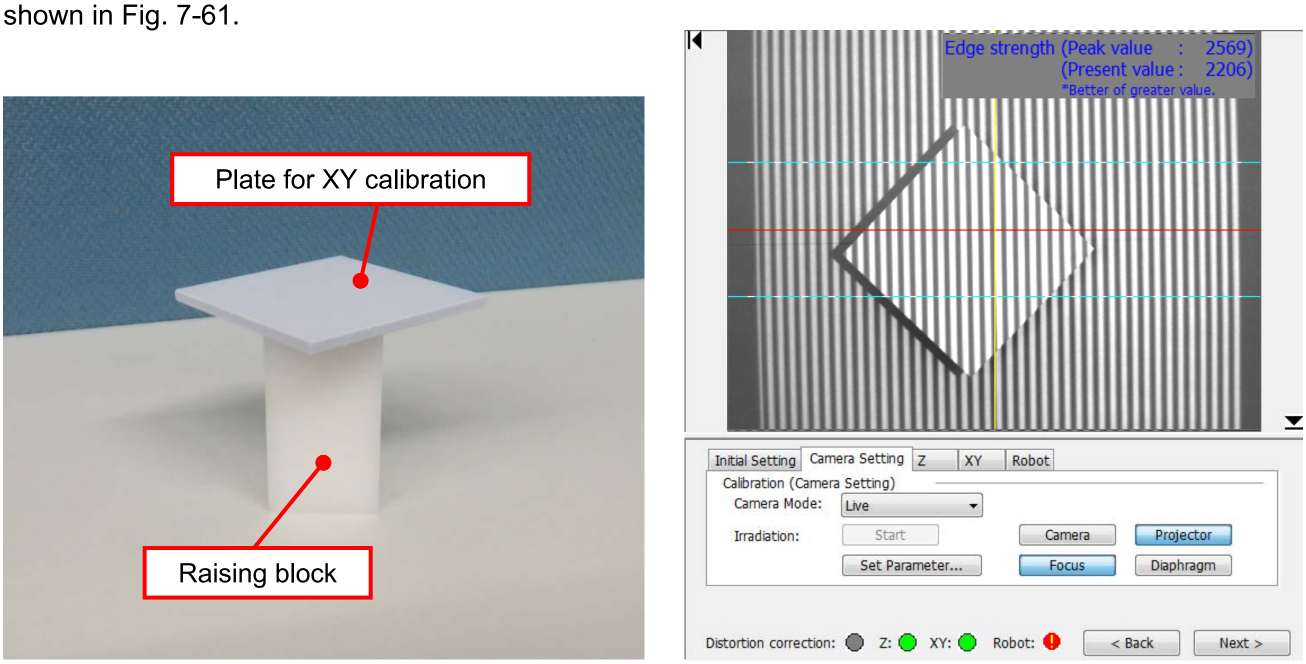


Fig. 7-60 XY calibration

Positioning the XY calibration plate in the camera head measurable range

Pattern irradiation on the camera setting screen: Click [Start] and then locate a plate for XY Calibration within the pattern irradiation. When doing so, place the square XY calibration plate in a slanted position as shown in Fig. 7-61.



Example of piling up the plate

Display screen for RT ToolBox2

Fig. 7-61 Location of the plate for XY Calibration

Performing XY calibration

Close the live image screen and click the [Close] button to perform the XY calibration. When it is completed, the recognition result is displayed on the image monitor. Furthermore, by performing the XY calibration, the red circle next to "XY:" in the setting/operation field changes to a green circle. An example of successful XY calibration is shown in Fig. 7-62.

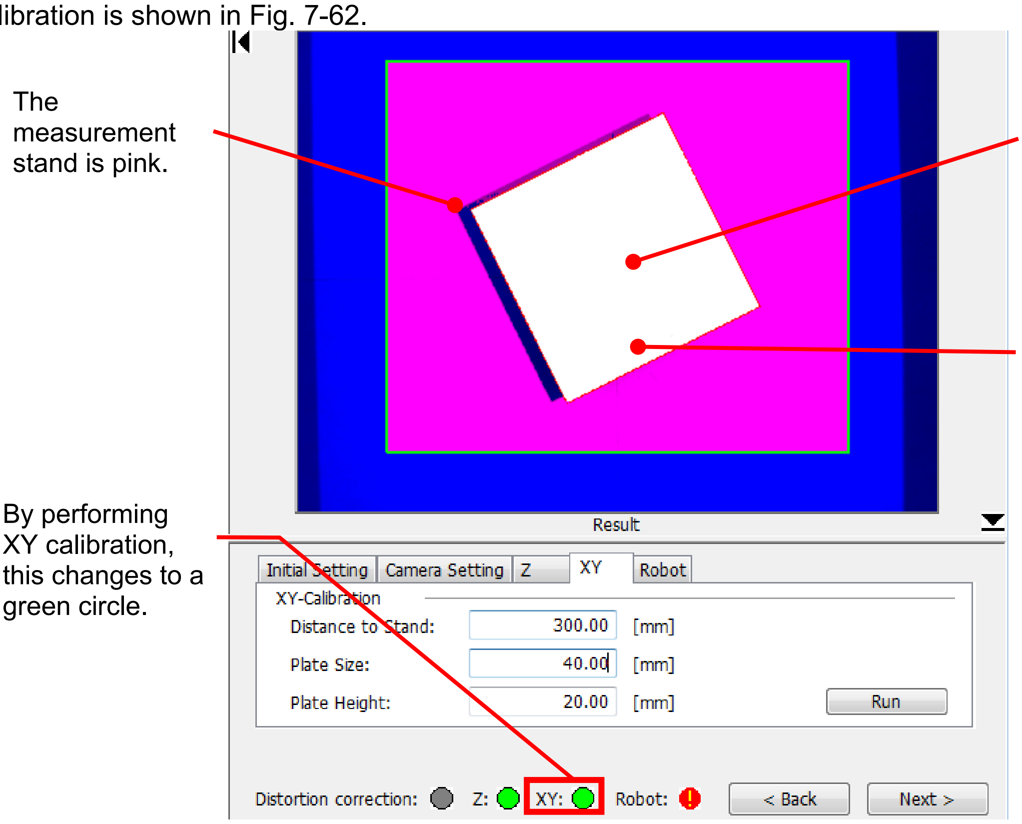


Fig. 7-62 Successful example of XY Calibration

Right-clicking the indicated image after the implementation of XY Calibration displays the average of the Z value centering on the position. The displayed value is the average (11x11 domain) of the measurement Z value centering on the clicked position.

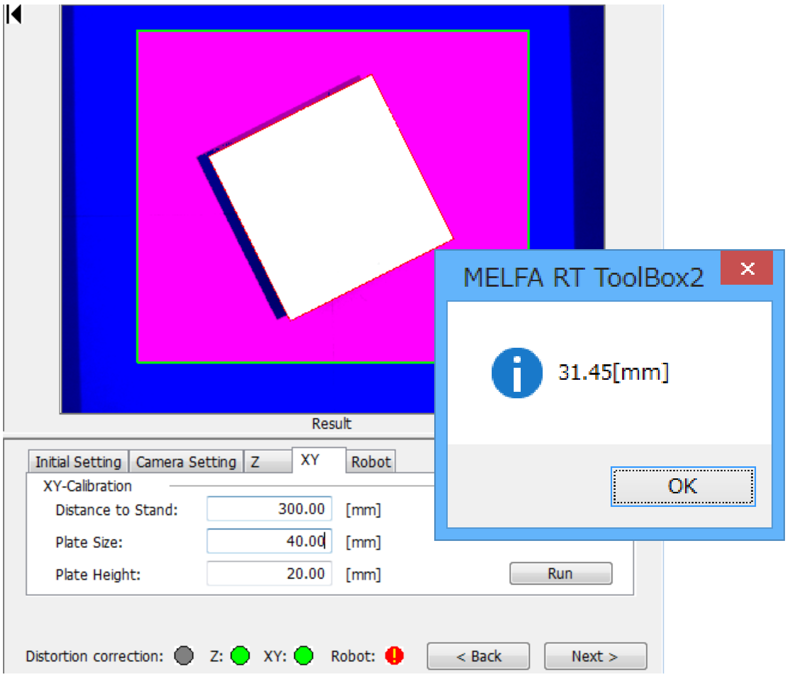


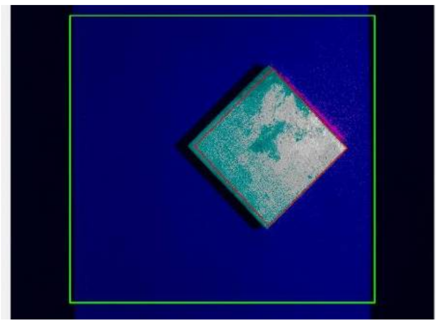
Fig. 7-63 Accuracy validation for calibration Z (display of the average Z value)

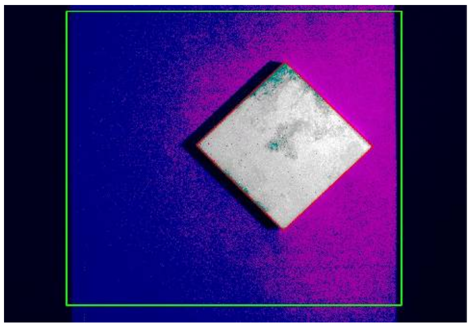
Check the following if the displayed image is not as shown in Fig. 7-62.

Table 7-6: Check items when XY calibration unsuccessful

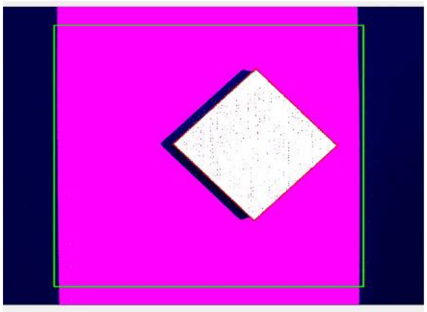
No.	Check item	Remedy
1	Are the values entered for the distance to the measurement stand, the plate size, and the plate height correct?	Ensure that the actual values are the same as the entered values.
2	Is there any ambient light [Note 1]?	Block any ambient light.
3	Is the glossy surface of the XY calibration plate facing up?	Use with the matte surface facing up.
3	Are there any blue areas inside the XY calibration plate at the image monitor [Note 2]?	The brightness may be insufficient. Adjust the camera aperture.
4	Are there any vertical pink lines inside the XY calibration plate at the image monitor [Note 3]?	Z calibration may have been unsuccessful. Perform Z calibration again.

Note 1: General lighting (fluorescent light, etc.) is also ambient lighting.
Note 2: Sample images are shown below.





Note 3: A sample image is shown below.



When the XY calibration is completed, click the [Next] button to proceed to robot calibration.

7.8.6. Robot calibration

A robot calibration is the operation for calculating the positional relationship between the robot and the camera. This operation varies depending on the robot type and camera set-ups (ex. hand eye / fixed camera). In addition, there are two different types of calibration methods. The first one for vertical 6-axis robot is a non-contact type method which recognizes a target mark at different robot poses. The second one for vertical 6-axis robot and horizontal 4-axis robot is a contact type method.

Table 7-7: Types of robot calibration

Type	Hand eye	Fixed camera	Features · Restriction
Non-contact	OK	OK	(1) Hand eye/Fixed camera is available (2) Teaching position errors have small influences to the calibration parameters. (3) Used for Vertical 6-axis robot only (4) Needed free space is big
Contact	NG	OK	(1) Fixed camera is only available (2) Teaching position errors have big influences to the calibration parameters. (3) Used for both Vertical 6-axis robot and Horizontal 4-axis robot (4) Needed free space is small

The robot calibration plate (2F-3DVS2-XYR-M/L) is used in different ways for robot calibrations with the hand eye and with the fixed camera when non-contact type method is used. The mark and camera positional relationship is changed based on the robot movement. Therefore, the robot calibration plate is fixed for the hand eye, and attached to the hand for the fixed camera. The robot calibration plates which are printed patterns (appendix 11.3) [Note 1] can be used.
Please note that robot calibration uses the robot calibration program (JRCA.prg) (see 11.2) contained in the CD-ROM provided. Please write the program to the robot controller beforehand.

◇◆◇Robot calibration plate◇◆◇
2F-3DVS2-XYR-M/L also serves as the XY calibration plate. Use the plate with the surface with a pattern shown in the following figure facing up. Pay attention not to use the plate with the plain surface facing up. Not doing so will cause a failure of the robot calibration.

◇◆◇Settings of the base or the tool◇◆◇
Changing the base settings or the tool settings from the default values will not affect the robot calibration.

In the contact type method, you can use the calibration sheet (appendix 11.4 [Note 1]). This method calculates the correspondence between the robot coordinate and the camera coordinate. This method recognizes five mark positions at the first and it gets each position of marks using the robot operation. For this operation, a tip part attached on the hand is needed for pointing the center of each mark. And also tool setting of the tip point is needed. If there is such a tip part in the hand, you can use it. If there is not, you have to prepare such a tip part in advance.

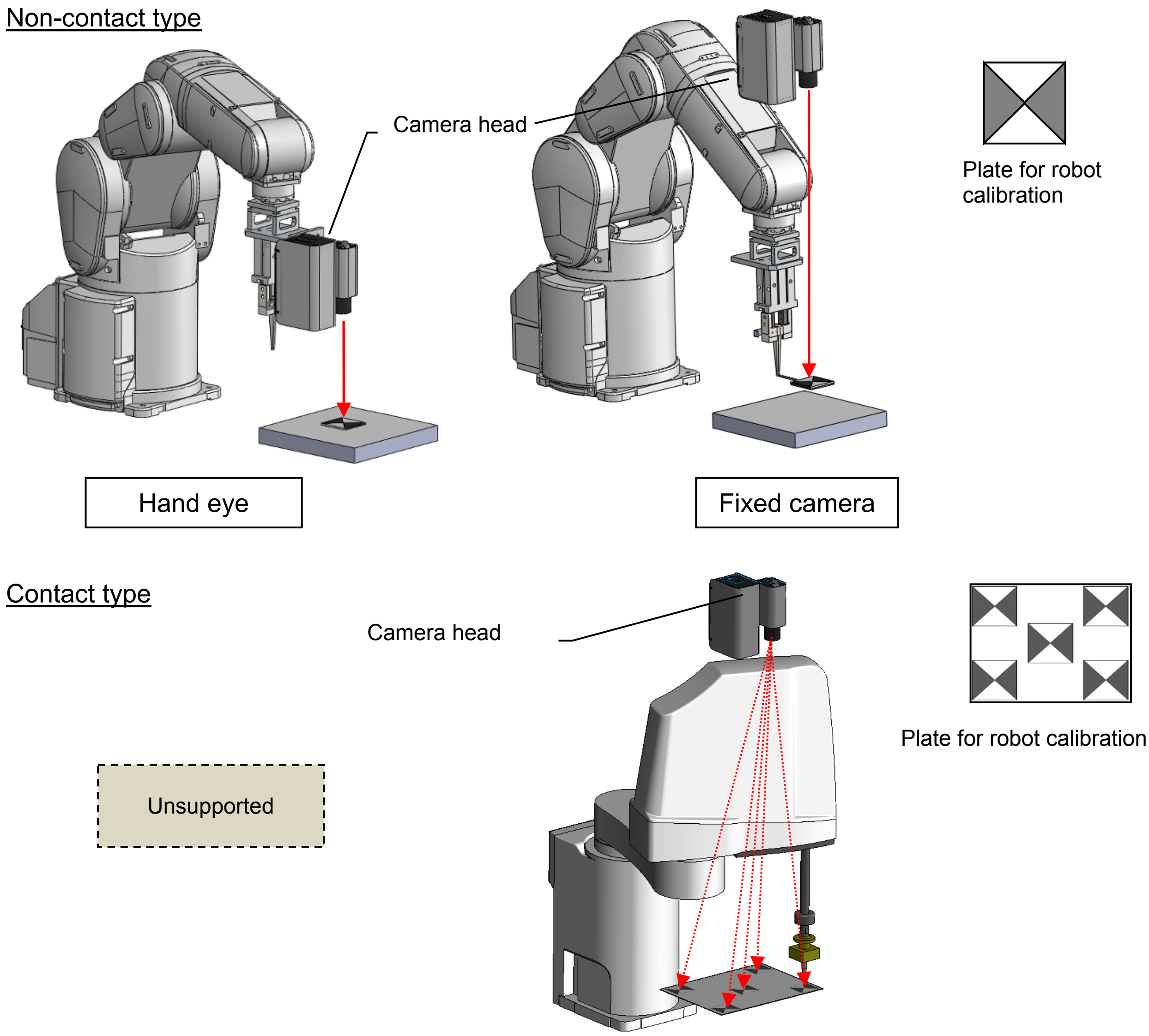


Fig. 7-64 Hand eye and fixed camera

Note 1: A calibration plate / sheet is stored in "JPN¥3DVS-Calibration_Marker_JPN¥Targetmarker.pdf" in the CD-ROM.

7.8.6.1. Hand eye (Non-contact type)

Teaching the calibration postures (8 points)

Operate the robot to check that a wide movement range can be secured for calibration without interfering with the surrounding environment. Determine the place to set a robot calibration plate (2F-3DVS2-XYR-M/L) on the measurement stand.
Set the camera mode to the live image, and then select (1) from the calibration postures (see Fig. 7-68). Jog the robot to achieve the positional relationship shown as the calibration posture (1) in Fig. 7-68. Set the distance between the robot calibration plate and the camera head to a height almost corresponding to the half of the "plate height" to which the Z calibration plate is raised Note 1. Furthermore, keep a perpendicular angle between the camera optical axis and the robot calibration plate. When the following conditions are satisfied, the alignment can be easily done by a hand alignment operation.

- The measurement stand is parallel to the robot installation surface.
- The camera coordinate system XY plane is parallel to either of the robot tool coordinate system XY plane, YZ plane, or ZX plane.

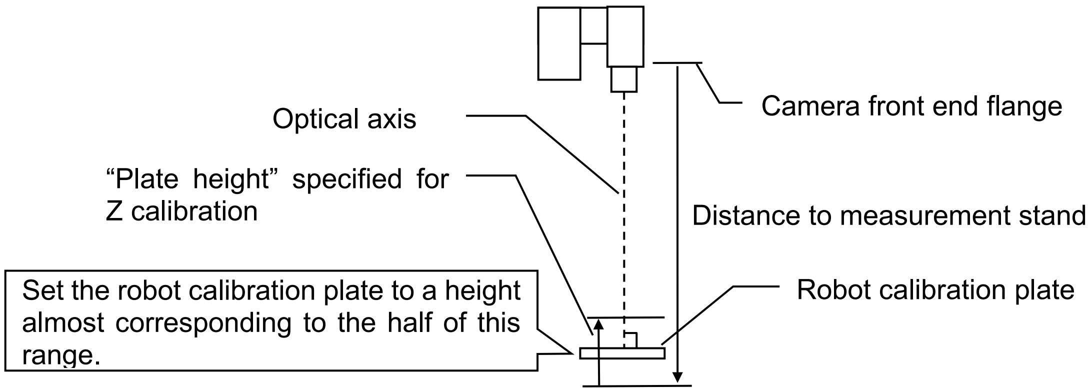


Fig. 7-65 Distance to robot calibration plate

Using the teaching guide displayed on the image monitor as reference, align the center of the robot calibration plate to be placed inside a red frame Note 2, which indicates the search area (see Fig. 7-66). The plate is not necessarily placed to be aligned with the center or the black and white pattern of the teaching guide.

Note 1: To ensure the best focus
Note 2: The center of the robot calibration plate is searched for inside the set area.

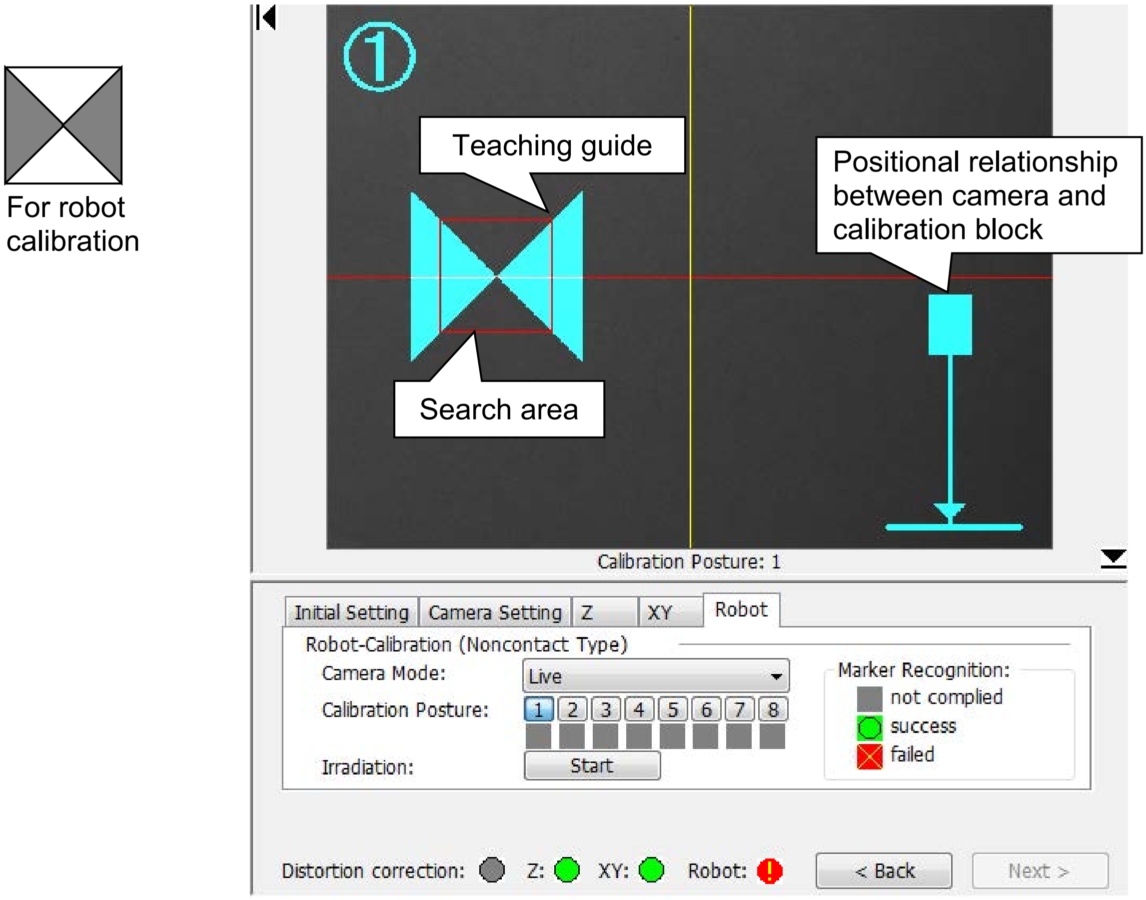


Fig. 7-66 Robot calibration

Click the pattern irradiation [Start] button in the setting/operation field to perform pattern irradiation, and ensure that the entire area inside the red frame falls within the pattern irradiation range. If not, click inside the image monitor and move the red frame to be included within the pattern irradiation range. When doing so, move the frame horizontally at a position as close to the teaching guide as possible. When it is necessary to also move the robot calibration plate, move the plate horizontally so that the center of the robot calibration plate comes on the red line on the image monitor.
Please note that this check is only required for the calibration postures (1) and (2).

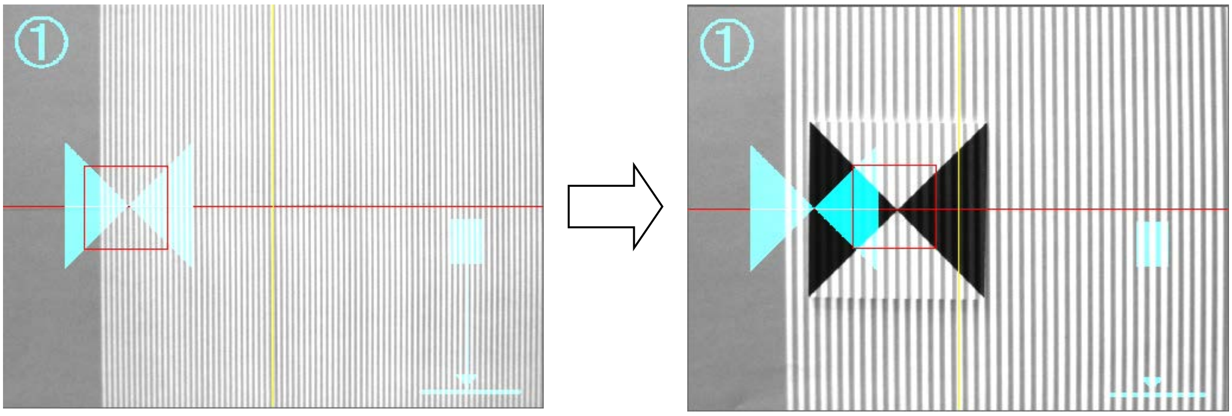
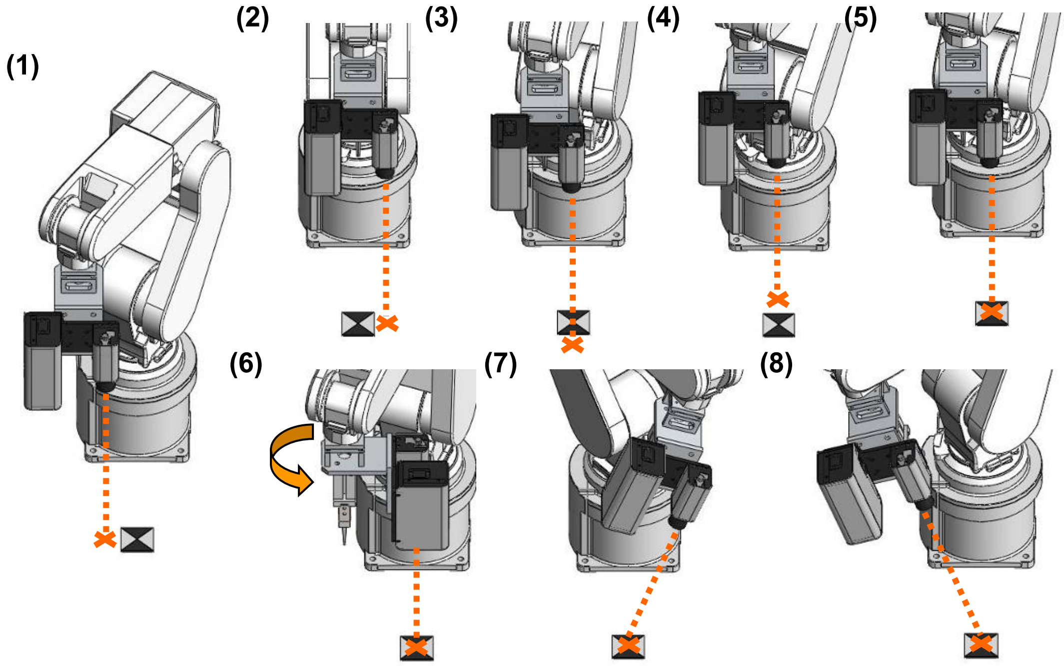


Fig. 7-67 Adjustment of the search range

Teach the adjusted position in the variable PG_CLB(1) in the calibration program "JRCA.prg" (contained in the CD-ROM provided).
Repeat the same operation as above for the calibration postures (2) to (8), and perform teaching in the variables PG_CLB(2) to (8) in the calibration program "JRCA.prg". For the calibration postures (7) and (8), however, it is necessary to tilt the camera optical axis against the robot calibration plate as shown in Fig. 7-68.
Do not change the height of the camera lens and the robot calibration plate for teaching of the calibration postures (2) to (6) from the height used for the posture (1). For the calibration postures (7) and (8), ensure that the height of the robot calibration plate is kept within the range shown in Fig. 7-65.



(1) to (5): Move in the XY-axis direction and align with the teaching guide. Do not change the A, B, or C components.
(6): Rotate 90º on the lens center and align with the teaching guide.
(7), (8): After moving to (5), move the A-axis ±20º, and then move the XY-axis to align it with the teaching guide.
When doing so, check the inclination while keeping an eye on the A-axis value in the orthogonal jog screen.
The B-axis may be rotated instead of the A-axis.

Fig. 7-68 Examples of robot movement when performing calibration

◇◆◇Calibration posture teaching method◇◆◇

- For teaching of the calibration postures (2) to (6), do not change the height of the camera lens and robot calibration plate for the position taught at the posture (1). For the calibration postures (7) and (8), ensure that the height of the robot calibration plate is kept within the range shown in Fig. 7-65.
- When teaching the calibration postures (2) to (8), it is easy to align the calibration jig with the teaching guide by jog operation after moving to the position of the taught calibration posture (1).
- With the calibration postures (7) and (8), tilt the robot by approximately 20º if there is sufficient space within the movement range. Tilt by approximately 15º, however, the robot movement range is insufficient.

Running calibration program "JRCA.prg"

Execute program "JRCA.prg" by the following procedure.

Table 7-8 Robot calibration program execution procedure

No.	Execution procedure
1	Lower the speed OVRD to 10% or lower.
2	Perform the joint jogging of the taught calibration postures (1) to (8) sequentially in the position edit screen of the teaching pendant and ensure that there is no interference with the surroundings.
3	Hold the teaching pendant and keep your finger over the stop button to ensure that robot movement can be stopped at any time, and then start automatic operation of the calibration program "JRCA.prg" by the robot controller.

When the program is started, the robot moves through the eight postures sequentially while performing block recognition. If robot calibration plate mark recognition is successful at each posture, a ○ mark appears below each calibration posture No. on the screen. The screen shown in Fig. 7-69 appears when the results for all eight postures are successful. The robot calibration can be completed depending on the displayed score.

Table 7-9: Required score for each recognition method

Recognition method	Required score
Model-less recognition	990 points or higher
Model matching recognition	995 points or higher

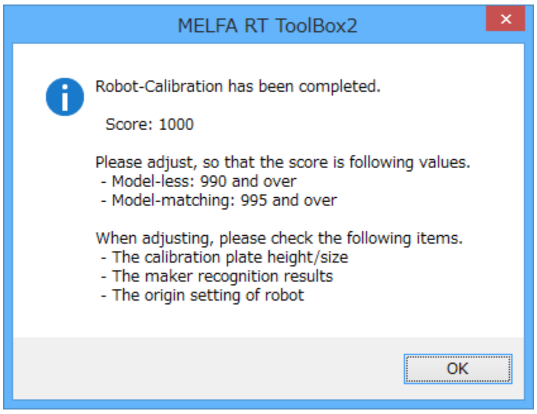


Fig. 7-69 Robot calibration score

If the robot calibration fails, check the following and perform robot calibration again.

Table 7-10: Check items when XY calibration unsuccessful

No.	Check item	Remedy
1	Is there any ambient light [Note 1]?	Block any ambient light.
2	When teaching the calibration posture, is the robot calibration plate at the range position shown in Fig. 7-65?	Jog the robot to the range position shown in Fig. 7-65.
3	When teaching the calibration posture, was the height of the camera lens or the robot calibration plate for postures (1) to (6) changed?	If the height of the camera lens or the robot calibration plate is changed, reteach the calibration posture.
4	Was an adjustment made to ensure that the pattern irradiation entered the red frame in the search area as shown in Fig. 7-67?	Adjust to ensure that the pattern irradiation enters the red frame in the search area as shown in Fig. 7-67.
5	Is the robot calibration plate shining due to specular reflection?	Change the calibration posture to a position with no specular reflection.
6	Is the robot origin setting correct?	Set the origin again. * Refer to the instruction manual, "Robot Arm Setup & Maintenance".

Note 1: Standard lighting (fluorescent light, etc.) is also ambient lighting.

If an L3142, L8610, or L8632 error occurs when executing the calibration program, refer to Nos. 4 to 6 in 10.3 Q&A.

◇◆◇If calibration fails◇◆◇
Angles are handled in radians in the program. If parameter "PRGMDEG" is "1", measurement will not be successful.

Proceed to the job creation when the robot calibration is completed.

7.8.6.2. Fixed camera (Non-contact type)

For the robot calibration for the fixed camera, attach the robot calibration plate (2F-3DVS2-XYR-M/L) to the hand.

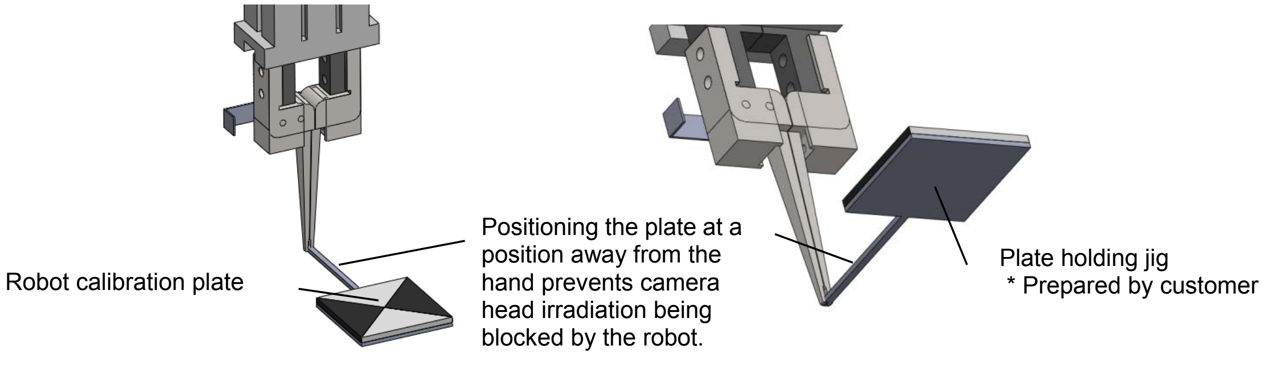


Fig. 7-70 Calibration plate attachment examples

◇◆◇Robot calibration plate attachment position◇◆◇
If the robot is not equipped with a hand, make sure to attach the robot calibration plate to the mechanical interface position or ahead.

<u>Teaching the calibration postures (8 points)</u>
Attach the robot calibration plate to the robot hand.

Set the camera mode to the live image, and then select (1) from the calibration postures. Jog the robot to achieve the positional relationship shown as the calibration posture (1) in Fig. 7-73. Set the distance between the robot calibration plate and the camera head to a height almost corresponding to the half of the "plate height" to which the Z calibration plate is raised [Note 1]. Furthermore, keep a perpendicular angle between the camera optical axis and the robot calibration plate. When the following conditions are satisfied, the alignment can be easily done by a hand alignment operation.

- The robot installation surface is parallel to the camera coordinate system XY plane.
- The robot calibration plate is parallel to either of the robot tool coordinate system XY plane, YZ plane, or ZX plane.

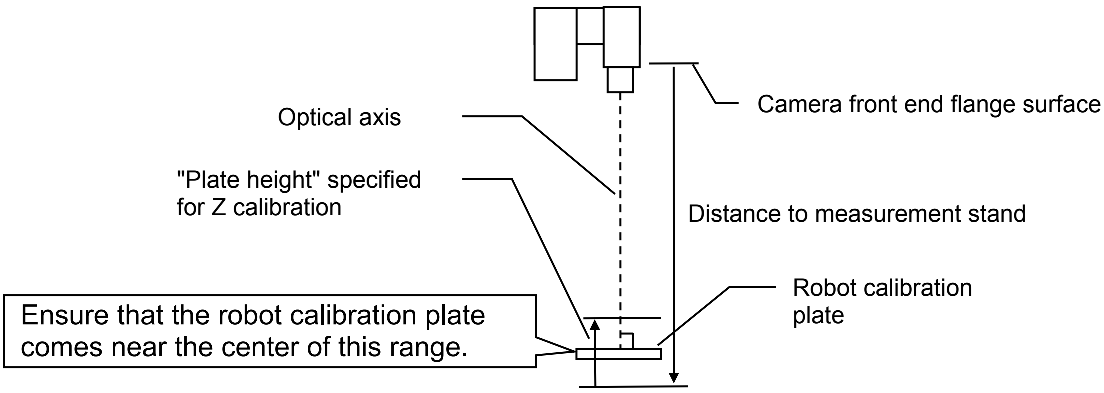


Fig. 7-71 Distance to robot calibration plate

Using the teaching guide displayed on the image monitor as reference, align the center of the robot calibration plate to be placed inside a red frame [Note 2], which indicates the search area (see Fig. 7-72). The plate is not necessarily placed to be aligned with the center or the black and white pattern of the teaching guide.

Note 1: To ensure the best focus
Note 2: The center of the robot calibration plate is searched for inside the set area.

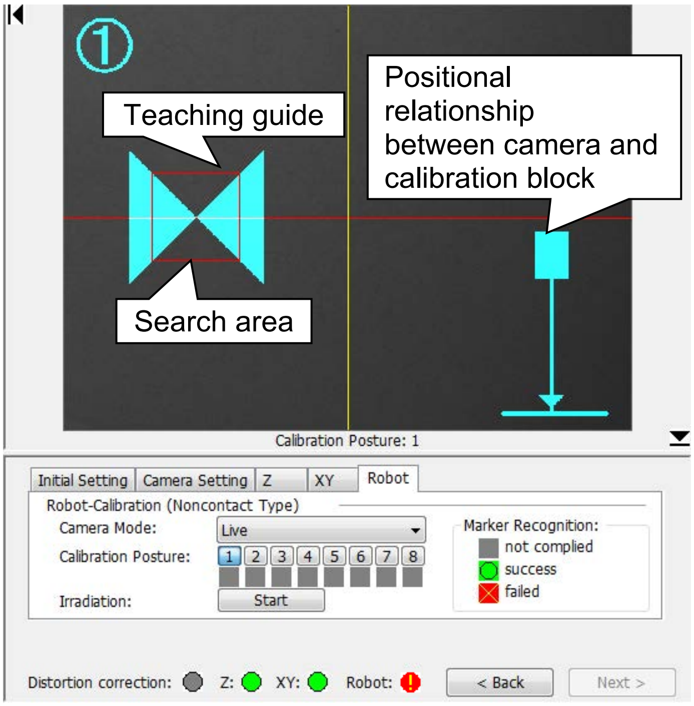


Fig. 7-72 Robot calibration

Click the pattern irradiation [Start] button in the setting/operation field to perform pattern irradiation, and ensure that the entire area inside the red frame falls within the pattern irradiation range. If not, click inside the image monitor and move the red frame to be included within the pattern irradiation range. When doing so, move the frame horizontally at a position as close to the teaching guide as possible. When it is necessary to also move the robot calibration plate, move the plate horizontally so that the center of the robot calibration plate comes on the red line on the image monitor.
Please note that this check is only required for the calibration postures (1) and (2).

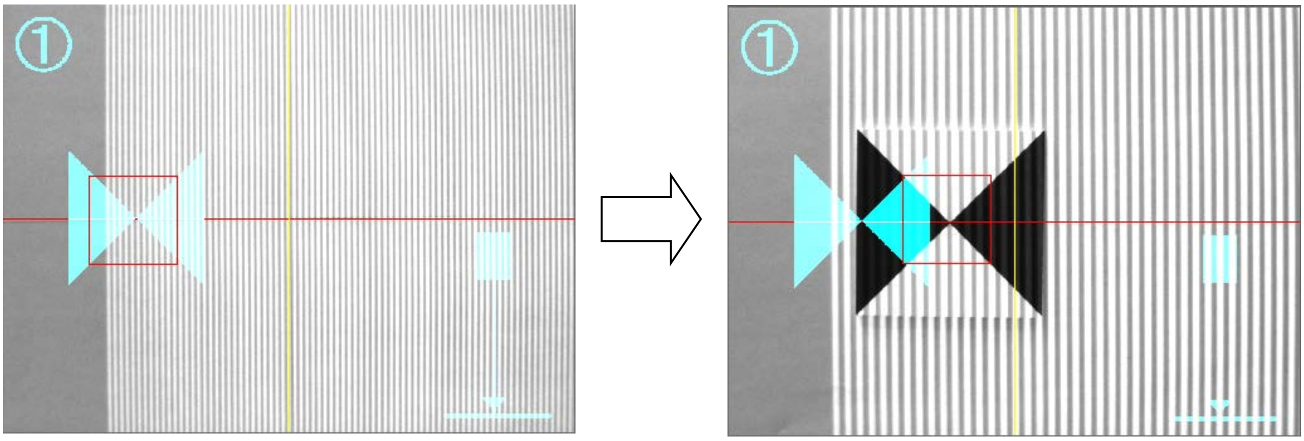
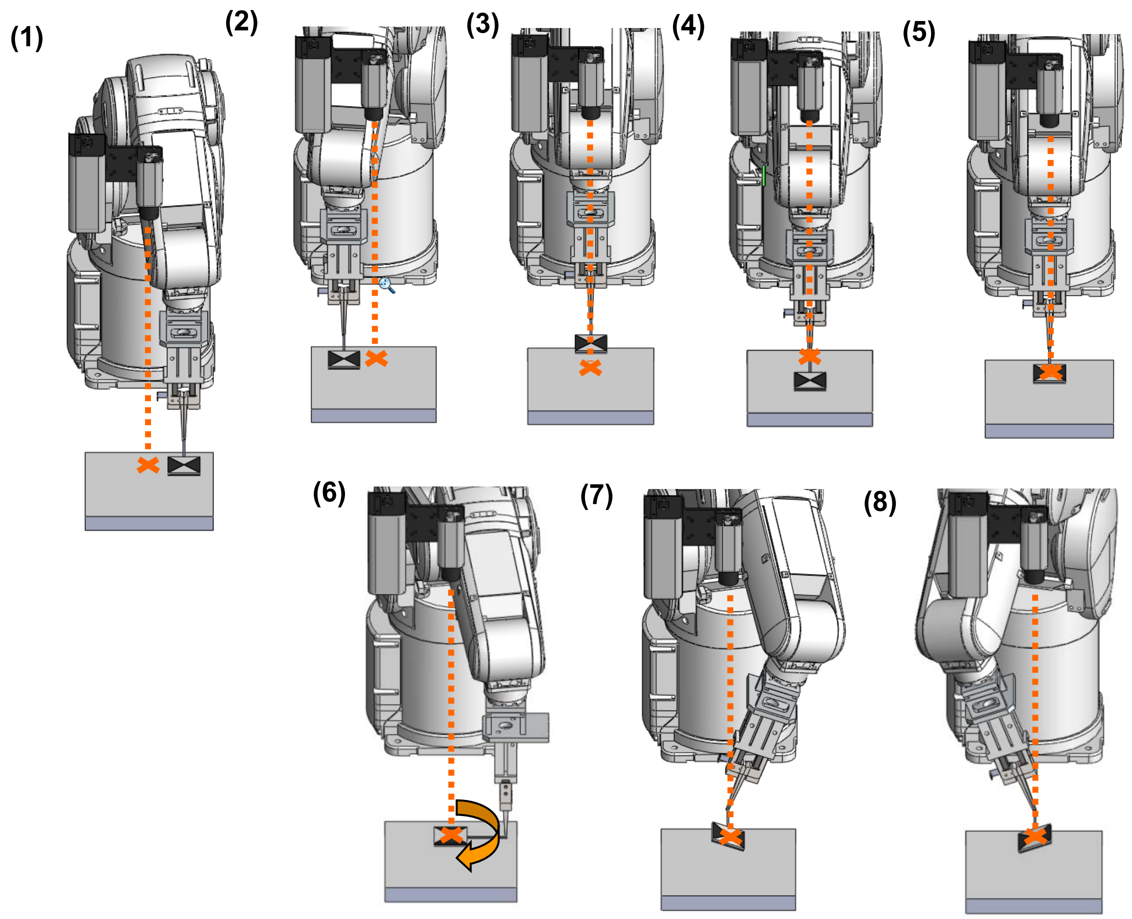


Fig. 7-73 Adjustment of the search range

Teach the position in the variable PG_CLB(1) in the calibration program "JRCA.prg" (contained in CD-ROM provided).
Repeat the same operation as above for the calibration postures (2) to (8), and perform teaching in the variables PG_CLB(2) to (8) in the calibration program "JRCA.prg". For the calibration postures (7) and (8), however, it is necessary to tilt the robot calibration plate against the camera optical axis.
Do not change the height of the camera lens and the robot calibration plate for teaching of the calibration postures (2) to (6) from the height used for the posture (1). For the calibration postures (7) and (8), ensure that the height of the robot calibration plate is kept within the range shown in Fig. 7-71.



(1) to (5): Move the XY-axis and align with the teaching guide. Do not change the A, B, or C components.
(6): Rotate 90° on the calibration mark center and align with the teaching guide.
(7), (8): After moving the B-axis ±20°, move the XY-axis to align it with the teaching guide.
When doing so, check the inclination while keeping an eye on the B-axis value in the orthogonal jog screen.
The A-axis may be rotated instead of the B-axis.

Fig. 7-74 Examples of robot movement when performing calibration

◇◆◇Calibration posture teaching method◇◆◇

- For teaching of the calibration postures (2) to (6), do not change the Z component for the position taught at the posture (1). For the calibration postures (7) and (8), ensure that the height of the robot calibration plate is kept within the range shown in Fig. 7-71.
- When teaching the calibration postures (2) to (8), it is easy to align the calibration jig with the teaching guide by jog operation after moving to the position of the taught calibration posture (1).
- With the calibration postures (7) and (8), tilt the robot by approximately 20°, if there is sufficient space within the movement range. Tilt by approximately 15°, however, if the robot movement range is insufficient.

Running calibration program "JRCA.prg"

Execute program "JRCA.prg" by the following procedure.

Table 7-11 Robot calibration program execution procedure

No.	Execution procedure
1	Lower the speed OVRD to 10% or lower.
2	Perform the joint jogging of the taught calibration postures (1) to (8) sequentially in the position edit screen of the teaching pendant and ensure that there is no interference with the surroundings.
3	Hold the teaching pendant and keep your finger over the stop button to ensure that robot movement can be stopped at any time, and start automatic operation of the calibration program "JRCA.prg" by the robot controller.

When the program is started, the robot moves through the eight postures sequentially while performing block recognition. If robot calibration plate mark recognition is successful at each posture, a ○ mark appears below each calibration posture No. on the screen. Screen Fig. 7-75 appears when the results for all eight postures are successful. The robot calibration can be completed depending on the displayed score.

Table 7-12: Required score for each recognition method

Recognition method	Required score
Model-less recognition	990 points or higher
Model matching recognition	995 points or higher

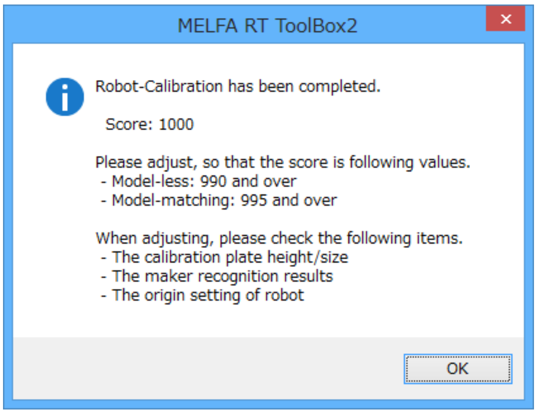


Fig. 7-75 Robot calibration score

If the robot calibration fails, check the following.

Table 7-13: Check items when XY calibration unsuccessful

No.	Check item	Remedy
1	Is there any ambient light [Note 1]?	Block any ambient light.
2	When teaching the calibration posture, is the robot calibration plate at the range position shown in Fig. 7-71?	Jog the robot to the range position shown in Fig. 7-71.
3	When teaching the calibration posture, was the height of the camera lens or the robot calibration plate for postures (1) to (6) changed?	If the height of the camera lens or the robot calibration plate is changed, reteach the calibration posture.
4	Was an adjustment made to ensure that the pattern irradiation entered the red frame in the search area as shown in Fig. 7-73?	Adjust to ensure that the pattern irradiation enters the red frame in the search area as shown in Fig. 7-73.
5	Is the robot calibration plate shining due to specular reflection?	Change the calibration posture to a position with no specular reflection.
6	Is the robot origin setting correct?	Set the origin again. * Refer to the instruction manual, "Robot Setup & Maintenance" in the instruction manual.

Note 1: Standard lighting (fluorescent light, etc.) is also ambient lighting.

If an L3142, L8610, or L8632 error occurs when executing the calibration program, refer to Nos. 4 to 6 in 10.3 Q&A.

◇◆◇If calibration fails◇◆◇
Angles are handled in radians in the program. If parameter "PRGMDEG" is "1", measurement will not be successful.

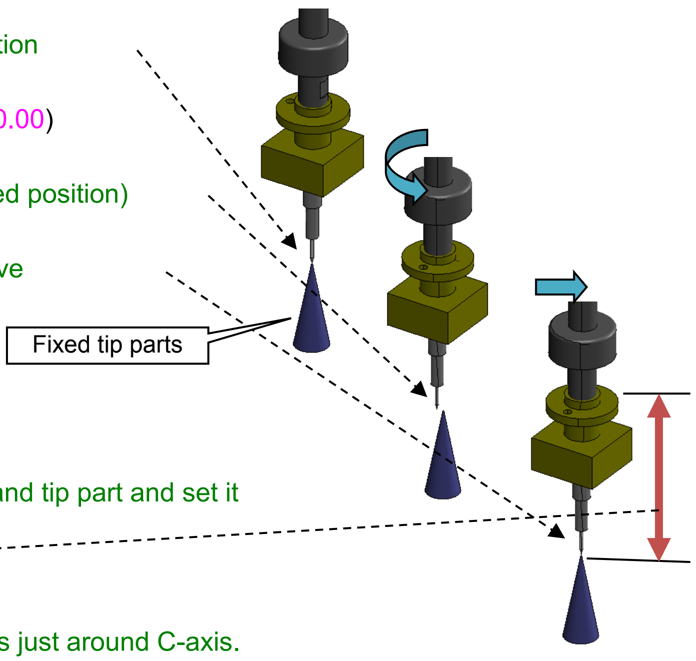
7.8.6.3. Fixed camera (Contact type)

The contact type method using fixed camera calculates he correspondence between the robot coordinate and the camera coordinate, by pointing the target marks which are recognized in the image plane. The tool setting operation for the tip parts to point the target marks is needed.

Tool point setting operation

Next robot program will help you to calculating the tool point setting parameters. For this operation, you should prepare fixed tip parts around the robot hand. After loading this program to the robot, you can run this program step according to the comments and get the parameters.

```
Tool P_NTool
'Set the tool downward, move to the 1st position
P0=P_Fbc
P91=P0*(+0.00,+0.00,+0.00,+0.00,+0.00,+90.00)
Mvs P91
'Rotate 90 degrees (the hand moves to shifted position)
PTL=P_Zero
'Shift the hand according to XY-axis just above
  'the fixed tip parts
P90=P_Fbc
PT=Inv(P90)*P0
PTL.X=(PT.X+PT.Y)/2
PTL.Y=(-PT.X+PT.Y)/2
'Measuring the length between flange and hand tip part and set it
  'as next parameter.
PTL.Z=150
Tool PTL
'Check whether does the hand tip part rotates just around C-axis.
Hlt
End
```



Teach 5 calibration poses

The contact-type robot calibration for the fixed camera please put five marks or calibration sheet, in the field of view of the camera. In that time, please be placed so that the mark is within the red frame in the robot calibration screen. When you click the "mark recognition" button, center positions of each mark will be detected.

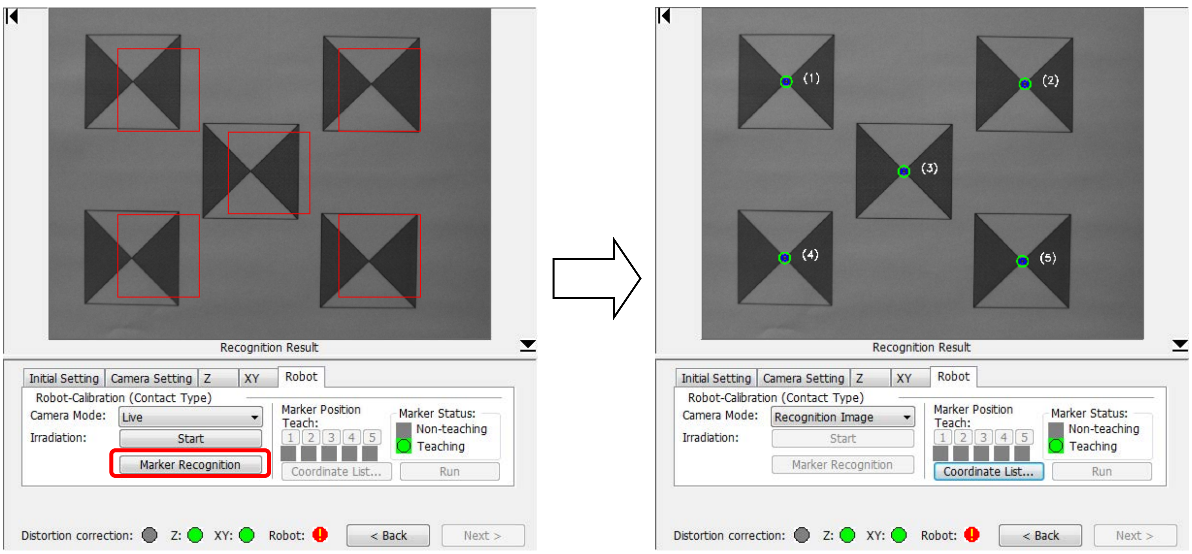


Fig. 7-76 Marker recognition

◇◆◇When a communication error with the robot occurs◇◆◇
The robot calibration will proceed with the communication with the robot, please complete the communication settings of the robot in advance.

After recognizing mark positions in image plane, to obtain robot positions by clicking the corresponding buttons with contacting each mark by the tip of the robot. After successful acquisition of each mark, each indicator will be changed to the "taught" position.

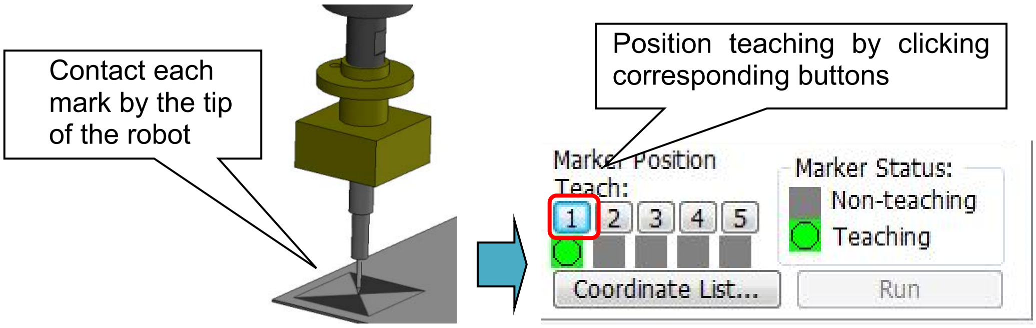


Fig. 7-77 Teaching operations at robot calibration

Please repeat this operation to each mark.

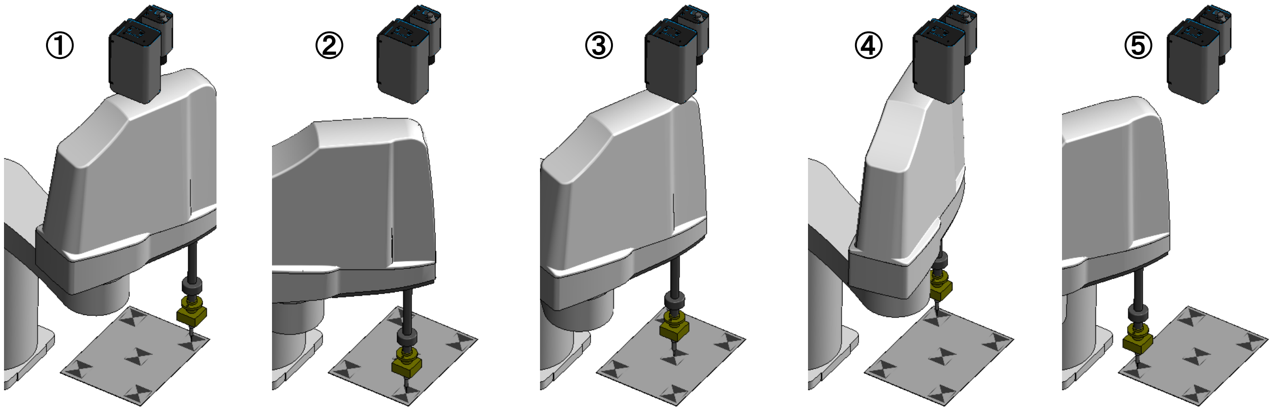


Fig. 7-78 Robot operation examples at robot calibrations

After teaching of all mark positions, the “Done” button will be ready. By clicking this button, the calibration parameters will be calculated.

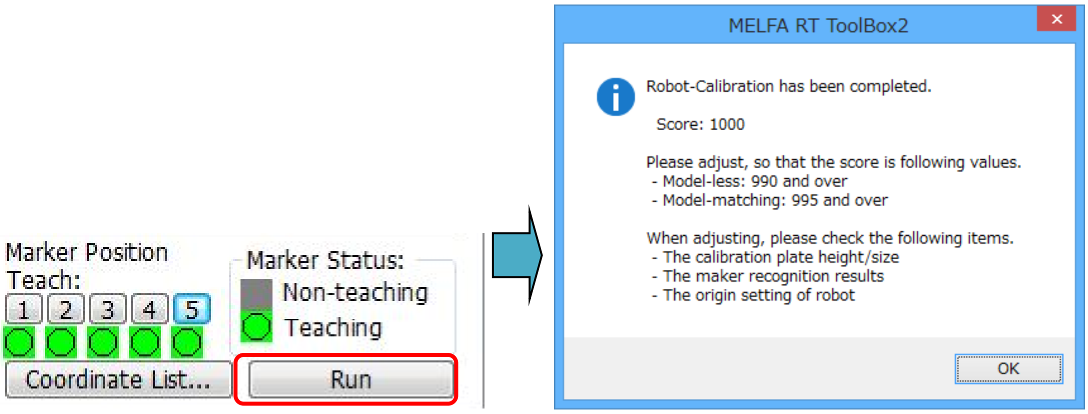


Fig. 7-79 Calculation of the robot calibration

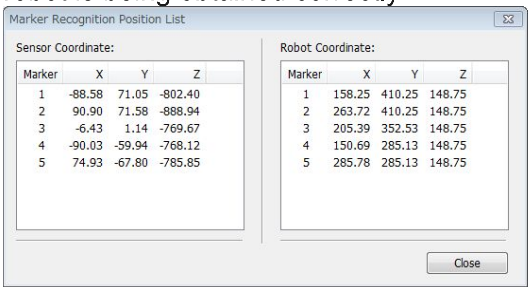
Please finish the operation of robot calibration by judging displayed score.

Table 7-14 Required score for each recognition method

Recognition method	Required score
Model-less recognition	990 points or higher
Model matching recognition	995 points or higher

When the robot calibration is failed, please check the following items.

Table 7-15 Check items when the robot calibration is failed

No.	Check items	Action
1	Is there disturbing light[*1)]?	Please shut off the disturbing light.
2	Are the marks of robot calibration sheet recognized correctly?	Please check mark center is being recognized correctly. When there is a positional error of the mark, please display a live image and try again to recognize the mark. Also, please teach again the robot position with touching marks.
3	Please check calibration sheet or not moving in accordance with the operation to go pointing the robot tip end.	If the calibration sheet had moved, please repeat the series of operations.
4	Please open the "Recognized mark position list", and make sure whether the position of the robot is being obtained correctly. 	Please try again the robot calibration after eliminating reasons of the problem. Ex. - Mis-setting of tool parameters - Getting robot position data from different robot
5	Please check the origin position data of the robot	Please set again the origin position data of the robot (*) Please refer the setup manual of the robot

*1) Ambient light (ex. room illumination) is a kind of the disturbing light.

7.9. Measurement and Recognition Settings

Register the measurement and recognition conditions in the job.
By clicking [Startup] - [3. Measurement/recognition] - [3-1 Create job] in the guidance menu of the MELFA-3D Vision setting screen, a Measurement/recognition screen appears.

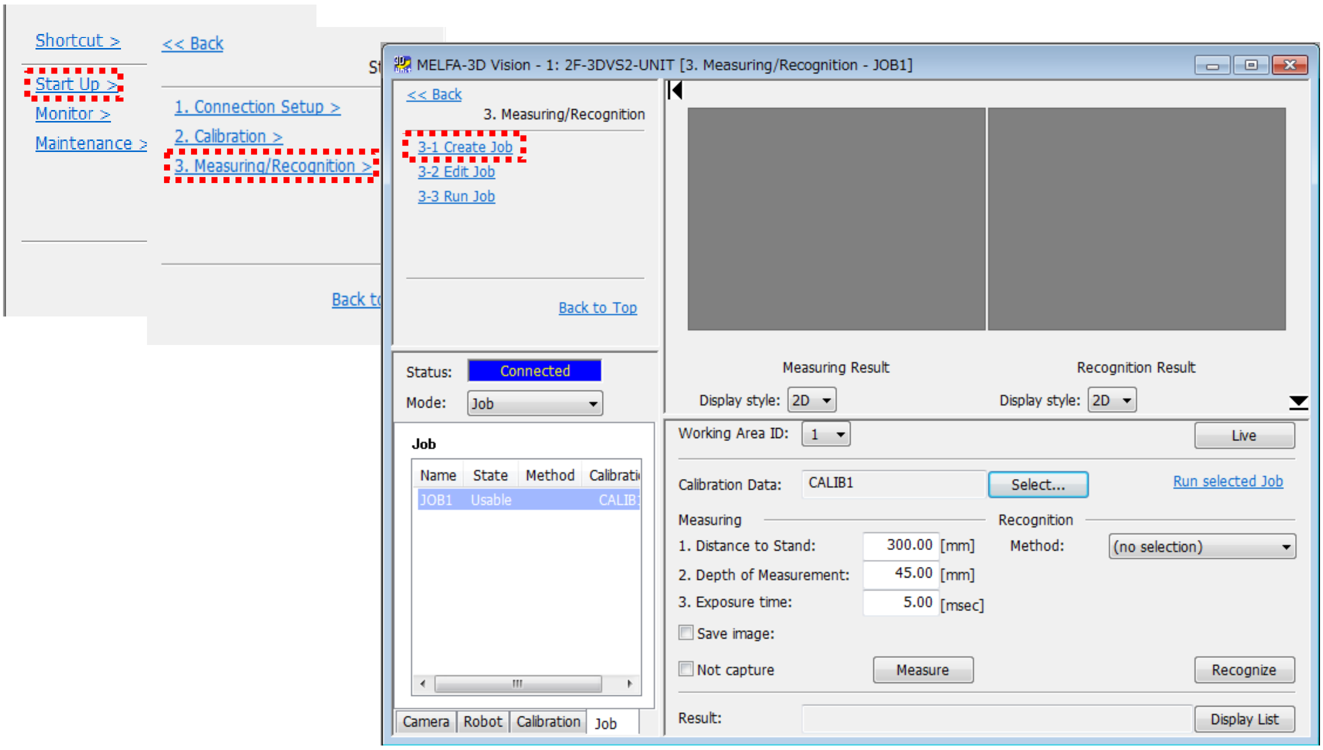


Fig. 7-80 Measurement/recognition

◇◆◇Creating new jobs◇◆◇
New jobs can be created by selecting from the context menu that appears when right-clicking the "Job" tab in the Properties window.

Editing existing jobs
If editing an existing job, click [Startup] - [3. Measurement/recognition] - [3-1 Edit job] to display a Select job screen, select the job to be edited, and then click the [Select] button.

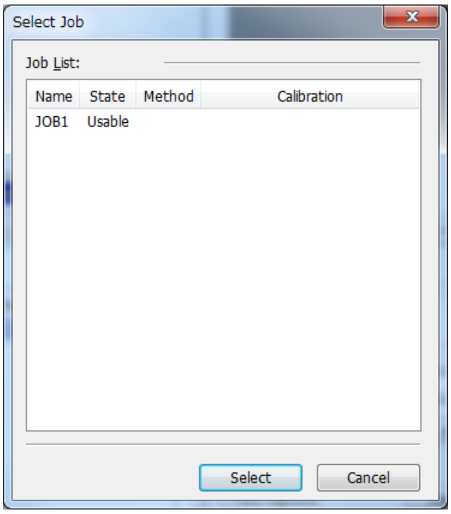


Fig. 7-81 Job selection

Changing the job name
If changing the job name, select the job tab in the Properties window, right-click the applicable job name, and then click [Rename] in the context menu that appears to change the name.

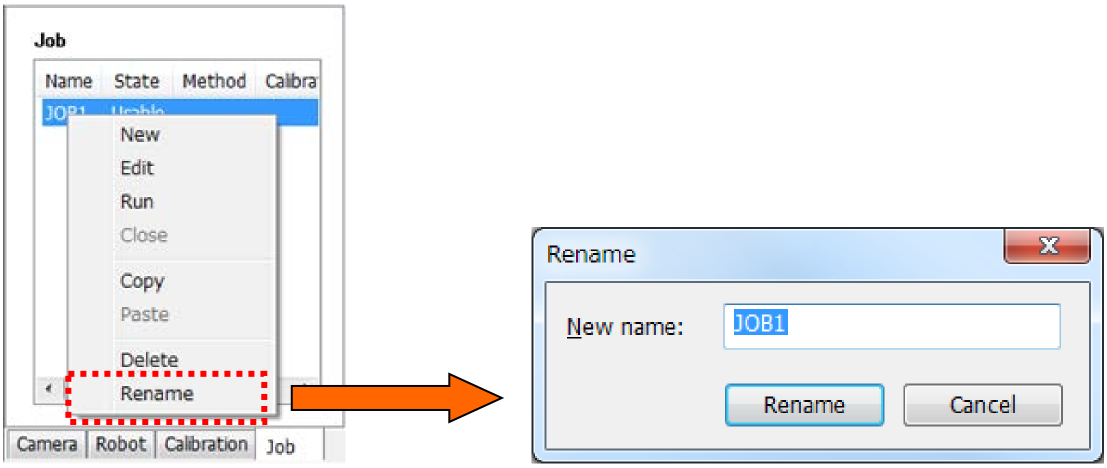


Fig. 7-82 Changing the job name

Deleting jobs
To delete a job, click [Delete] in the context menu. However, jobs that are being edited cannot be deleted. To close the Edit screen, click [MELFA-3D Vision] - [Close job] on the menu bar.

7.9.1. Job creation and execution

For creating a jog, measurement and recognition settings are required.

7.9.1.1. Selecting the workspace ID and the calibration data

To perform measurement and recognition, select the ID of the workspace to be used and the calibration data. The workspace is an area to temporarily retain the captured images and range images obtained when performing measurement and the results and recognition images obtained when performing recognition. Please note that the setting for the workspace ID selected here is not saved to the job. The selected workspace is used only when the [Measure] button is clicked in this screen.

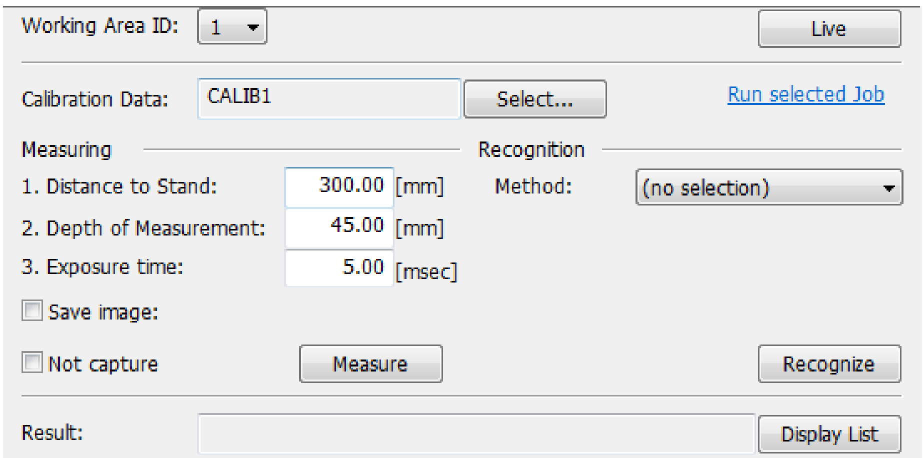


Fig. 7-83 Measurement/recognition settings

7.9.1.2. Measurement settings

<u>Input the distance to the measurement stand, measurement depth and exposure time.</u>

Enter the following values.

Table 7-16: Measurement parameters

Item	Description	Remarks
Distance to Stand	Distance from the camera lens mounting base (camera front end flange surface) to the measurement stand	If misrecognition occurs by measuring the measurement stand or the bottom of the supply box, shorten the distance within the range in which workpiece measurement is possible to ensure that the measurement stand is not measured. (Particularly with suction hands)
Depth of Measurement	Target range of measurement based on the position specified at "Distance to measurement stand"	Determine the depth from the estimated workpiece stacking height. It is necessary that the height from the measurement stand be less than the plate height specified for performing Z calibration.
Exposure time	Camera exposure time (time interval that a sensor is exposed to light, shutter speed)	

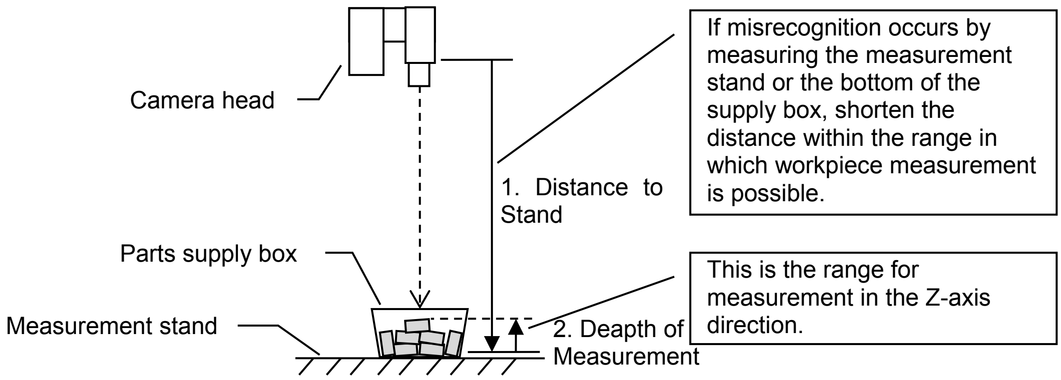


Fig. 7-84 Distance to measurement stand and measurement depth

◇◆◇Parts supply box◇◆◇

If the parts supply box has an irregular bottom surface as shown in the drawing in the middle above, the robot may grip the bottom surface. If the bottom surface is inclined as shown in the drawing on the right, the function to detect the remaining workpieces will not work properly. Consequently, check that the parts supply box has a flat even bottom surface.

<u>Select the "Save measurement data" and "Do not capture" check boxes if required.</u>

Select the following check boxes if required. Please note that the settings selected with these check boxes are enabled only when the [Measure] button is clicked. Since **they are not enabled by executing the job**, caution is advised.

Table 7-17 Measurement options

Item	Description	Remarks
Save measurement data	By selecting this check box and setting the save destination, captured images (23) and range images obtained when performing measurement are saved.	By selecting this check box, the save destination and [Browse] button appear.
Do not capture	By selecting this check box, no images are captured, range images are calculated from captured images temporarily saved to the specified workspace, and the calculated images appear in the measurement results.	Used to obtain range imaged under different conditions for the same measurement images.

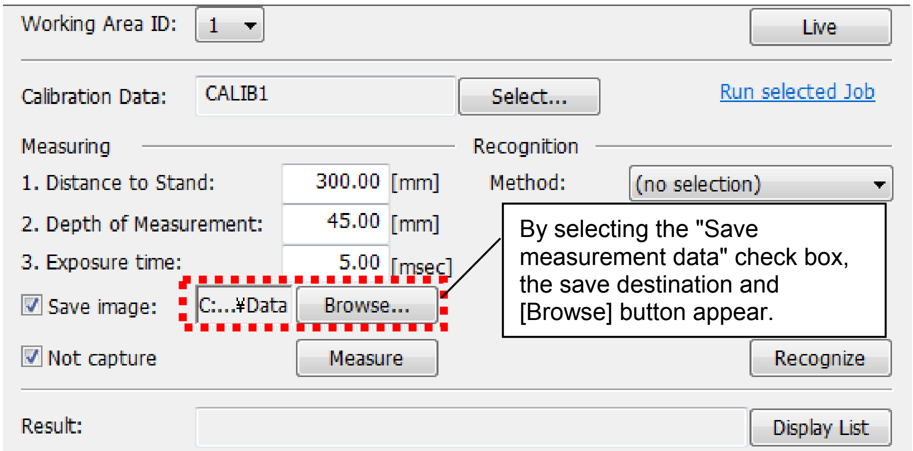
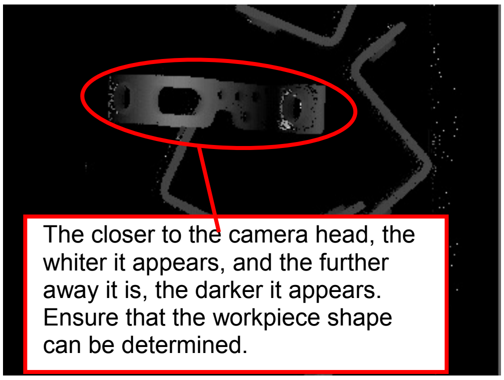


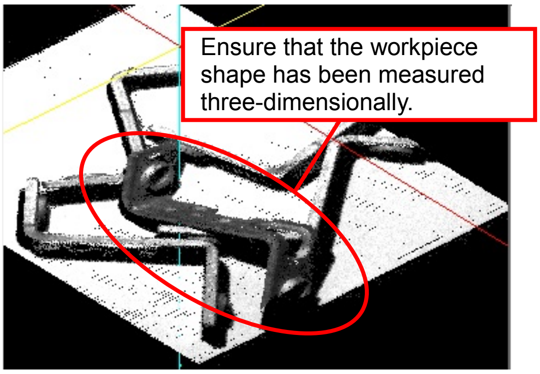
Fig. 7-85 Check box for "Save the measured data"

Checking the measurement results

Place a workpiece inside the measurable area and click the [Measure] button to perform measurement. If using the 2D display, a range image is displayed, and the closer it is to the camera head, the whiter it appears, and the further away it is, the darker it appears. Check whether the image looks like the expected range image with respect to the measured workpiece. Furthermore, switch to the 3D display, and ensure that the workpiece shape has been measured three-dimensionally.



2D display



3D display

Fig. 7-86 Measurement results check

◇◆◇Distance to measurement stand and measurement depth◇◆◇

The distance to the measurement stand and the measurement depth are specified in [mm], however, these values are calculated based on information obtained by performing calibration. If the measurement result does not improve, return to calibration for readjustment.

7.9.1.3. Recognition settings

There are two recognition methods, model-less recognition that does not require a workpiece 3D model, and model matching recognition that requires workpiece models to be registered.
The model matching recognition is only supported in "4F-3DVS2-PKG1". It is not in use in "4F-3DVS2-PKG2".

(1) Model-less recognition

Model-less recognition is a method used for bin picking, where hand information is used to detect gaps into which insertion is possible, or flat surfaces from which pickup is possible, for direct approach from directly above to the parts supply box. High speed bin picking can be achieved with a little operation amount. Since the approach is from directly above, **only the X, Y, Z, and C position data components are valid**.
For the direct approach to the parts supply box, it is necessary to consider the possibility of interference between the hand and the parts supply box. Therefore, design the hand by referring to "7.10.1 Hand claw shape".

<u>Selecting the recognition method</u>

Select "Model-less" from the drop-down menu.

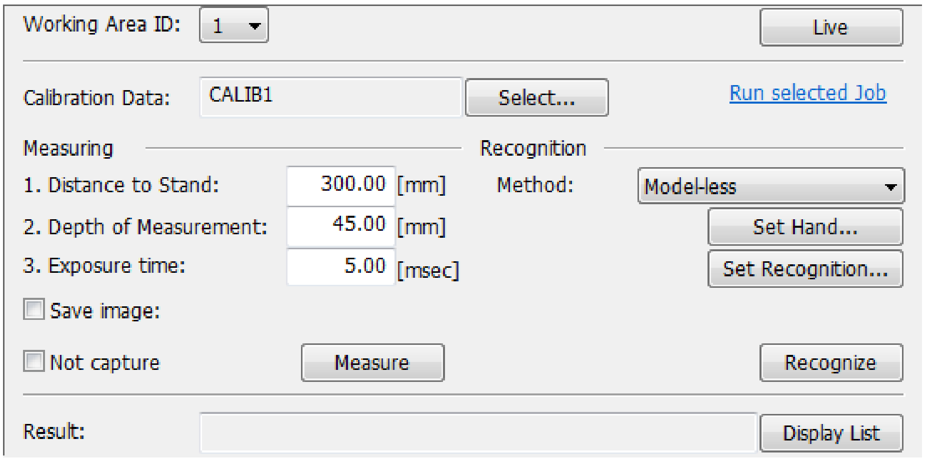


Fig. 7-87 Selection of recognition methods (model-less recognition)

The table below describes the buttons that appear when the model-less matching is selected.

Table 7-18: Hand settings and recognition settings

Item name	Description	Remarks
Set Hand	A Hand settings screen appears. The Hand settings screen is used to set the hand types and the corresponding parameters.	
Set Recognition	A Model-less recognition user settings screen appears. This screen is used to select the hand type to be used from those registered in the hand settings, and to set recognition parameters.	

<u>Specifying settings for the used hand</u>

By clicking the [Set Hand] button, the Hand settings screen appears. Click the [Add] button at the Hand settings screen.

Enter the "Name [Note 1]", "Type", and "Parameter" for the hand being registered in the Hand addition screen.
"Parameter" can be edited by selecting the parameter name and clicking the [Change] button.
Refer to Table 7-19 for hand types and parameters for which settings are required. By clicking the [Set] button, the hand is added.

Note 1: Up to 32 single-byte alphanumeric characters

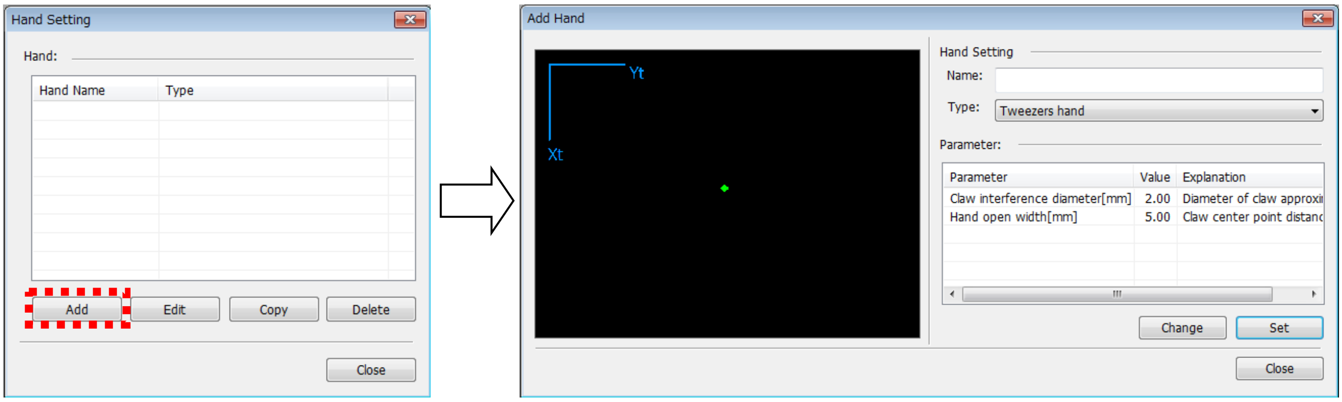


Fig. 7-88 Hand settings

This system provides hands roughly classified to 3 types (Tweezers, Suction and Parallel).

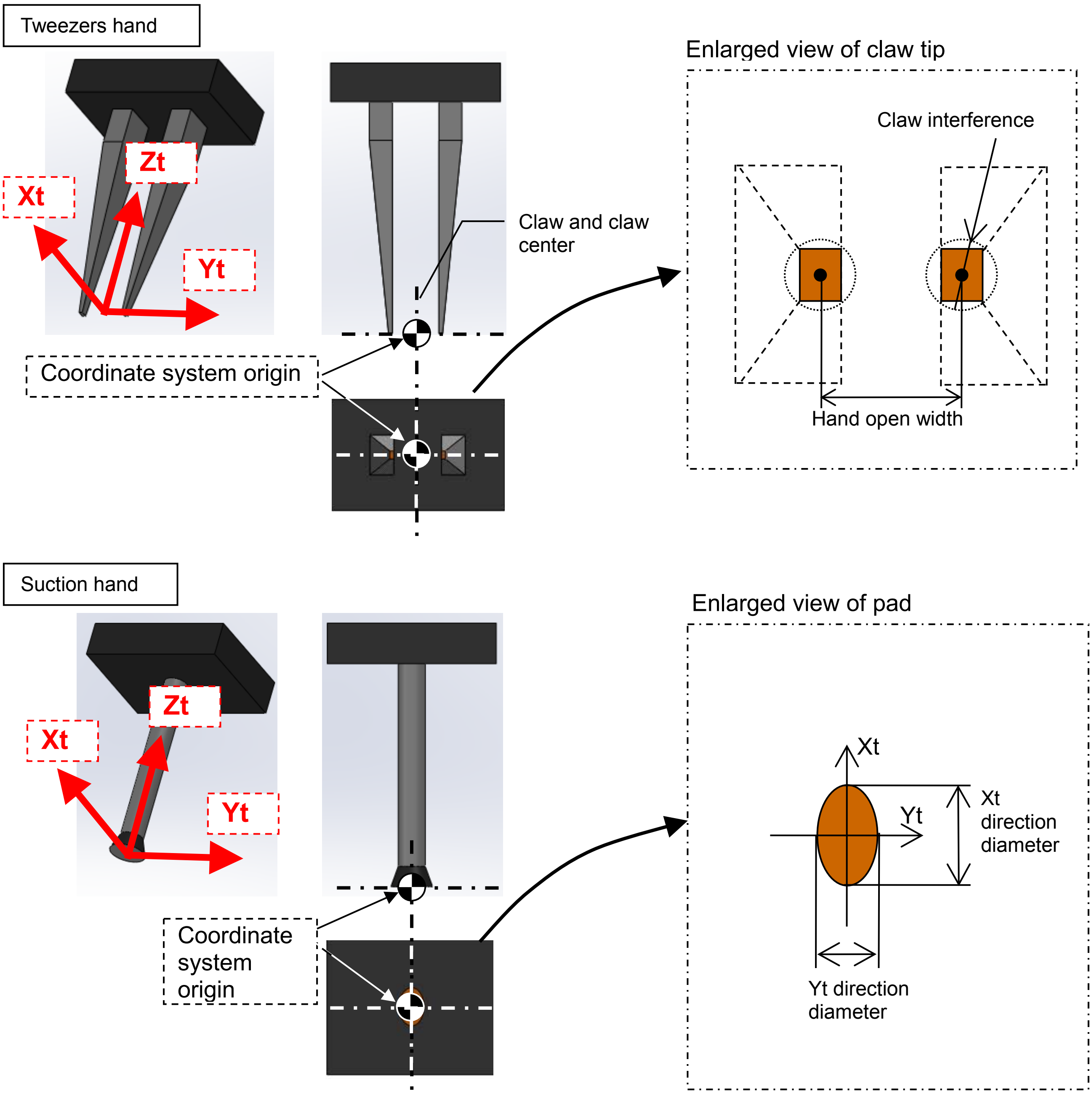


Fig. 7-89 (a) Hand coordinate system and hand parameters (Tweezers, Suction Hand)

Parallel hand

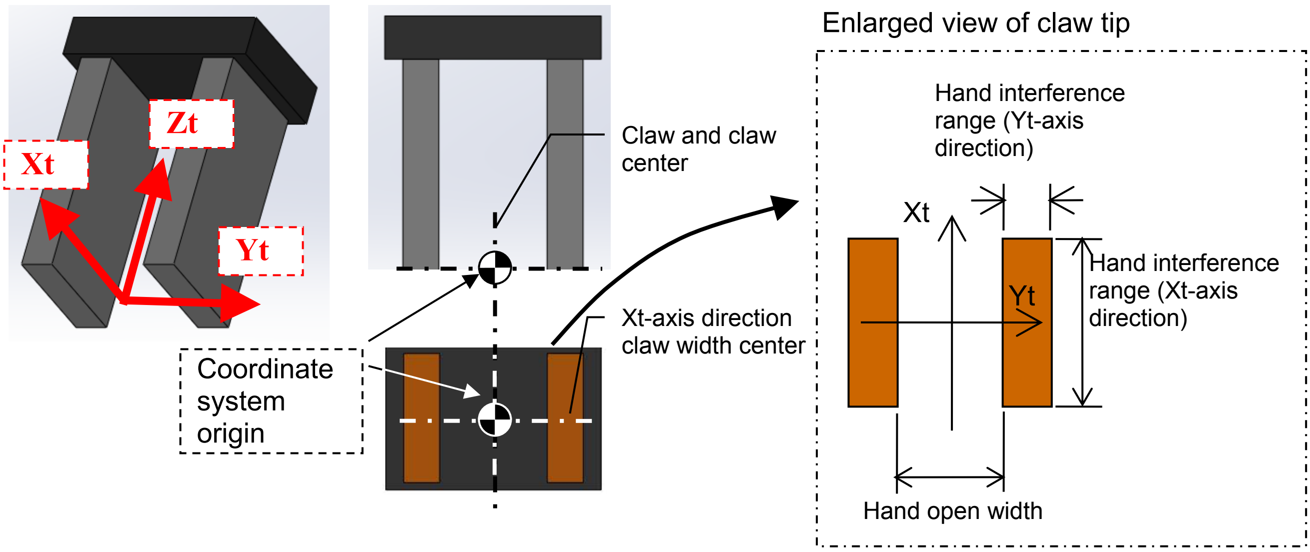
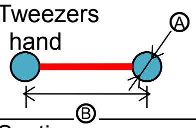
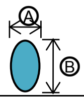
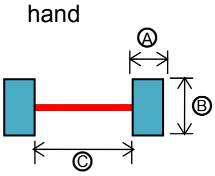
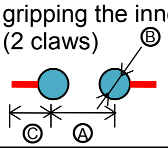
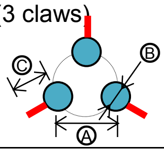
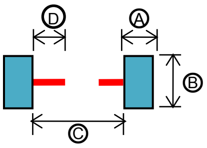
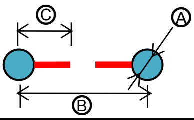
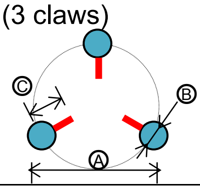
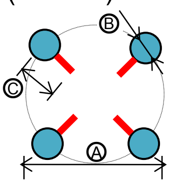


Fig. 7-90 (b) Hand coordinate system and hand parameters (Parallel hand)

In the following part, the features and parameters for each hand are described.

Table 7-19 : Hand types and parameters

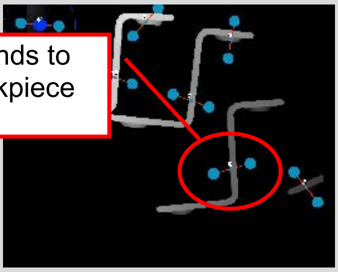
Hand type	Parameter	Unit	Description	Range	Default setting
Tweezers hand 	Claw interference diameter Ⓐ	mm	Diameter of claw approximated with circle	0.5 to 50	2
	Hand open width Ⓑ	mm	Claw center point distance when hand open	0.5 to 200	5
Suction hand 	Yt-axis direction diameter Ⓐ	mm	Yt-axis direction diameter in hand coordinate system	0.5 to 100	2
	Xt-axis direction diameter Ⓑ	mm	Xt-axis direction diameter in hand coordinate system	0.5 to 100	2
Parallel hand 	Hand interference range (Yt-axis direction) Ⓐ	mm	Yt-axis direction claw length in hand coordinate system	0.5 to 100	1
	Hand interference range (Xt-axis direction) Ⓑ	mm	Xt-axis direction claw length in hand coordinate system	0.5 to 100	1.5
	Hand open width Ⓒ	mm	Claw inner side distance when hand open	0.5 to 200	5
Tweezers hand gripping the inner (2 claws) 	Hand close width Ⓐ	mm	Claw inner side distance when hand close	0.5 to 200	5
	Claw interference diameter Ⓑ	mm	Diameter of claw approximated with circle	0.5 to 50	2
	Hand close stroke Ⓒ	mm	Claw moving length when hand close	0.5 to 100	5
Tweezers hand gripping the inner (3 claws) 	Claws group interference diameter Ⓐ	mm	Diameter of interference area consists of claws when hand close	0.5 to 200	10
	Claw interference diameter Ⓑ	mm	Diameter of claw approximated with circle	0.5 to 50	2
	Hand close stroke Ⓒ	mm	Claw moving length when hand close	0.5 to 100	5

Hand type	Parameter	Unit	Description	Range	Default setting
Parallel Hand (Limited stroke) 	Hand interference range (Yt-axis direction) Ⓐ	mm	Yt-axis direction claw length in hand coordinate system	0.5 to 100	1
	Hand interference range (Xt-axis direction) Ⓑ	mm	Xt-axis direction claw length in hand coordinate system	0.5 to 100	1.5
	Hand open width Ⓒ	mm	Claw inner side distance when hand open	0.5 to 200	5
	Hand close stroke Ⓓ	mm	Claw moving length when hand close	0.5 to 200	1
Tweezers hand (Limited stroke) 	Claw interference diameter Ⓐ	mm	Diameter of claw approximated with circle	0.5 to 50	2
	Hand open width Ⓑ	mm	Claw inner side distance when hand open	0.5 to 200	5
	Hand close stroke Ⓒ	mm	Claw moving length when hand close	0.5 to 200	1
Tweezers hand (3 claws) 	Claws group interference diameter Ⓐ	mm	Diameter of interference area consists of claws when hand open	0.5 to 200	10
	Claw interference diameter Ⓑ	mm	Diameter of claw approximated with circle	0.5 to 50	2
	Hand close stroke Ⓒ	mm	Claw moving length when hand close	0.5 to 200	1
Tweezers hand (4 claws) 	Claws group interference diameter Ⓐ	mm	Diameter of interference area consists of claws when hand open	0.5 to 200	10
	Claw interference diameter Ⓑ	mm	Diameter of claw approximated with circle	0.5 to 50	2
	Hand close stroke Ⓒ	mm	Claw moving length when hand close	0.5 to 200	1

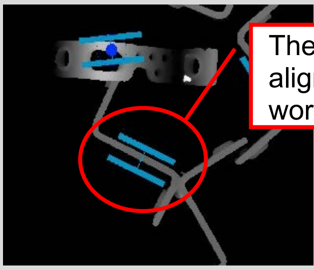
◇◆◇Difference between tweezers hand and parallel hand◇◆◇

- The tweezers hand recognition speed is faster than that of the parallel hand.
- When gripping workpieces, the parallel hand is able to grip more steadily than the tweezers hand.
  - * The claw angle of the parallel hand is aligned along with the workpiece shape. Therefore, the parallel hand does not tend to rotate when gripping a workpiece.

The claw angle tends to tilt toward the workpiece shape.



Tweezers hand



Parallel hand

The claw angle is aligned along with the workpiece shape.

◇◆◇Registered hand settings◇◆◇

Hand settings created and registered here can also be used for other jobs.

<u>Specifying recognition settings</u>

Clicking [Set recognition] displays the model-less recognition user setting window.

Select a hand to use from the pull-down and then change the recognition parameters as needed. To change them, select the parameter to change from the list of recognition parameters, and then click [Change]. Enter a value at the displayed Parameter change screen and click the [Set] button.

By clicking the [Set Area] button and dragging on the image, the recognition range can be set. The range specified here is reflected to the recognition range of the recognition parameter (Recognition range X start point,

Recognition range X end point, Recognition range Y start point, Recognition range Y end point).
By clicking the [Set Floor Height] button and clicking the location to be set as the floor on the image, the height of the selected location is applied to the recognition parameter bin floor height.

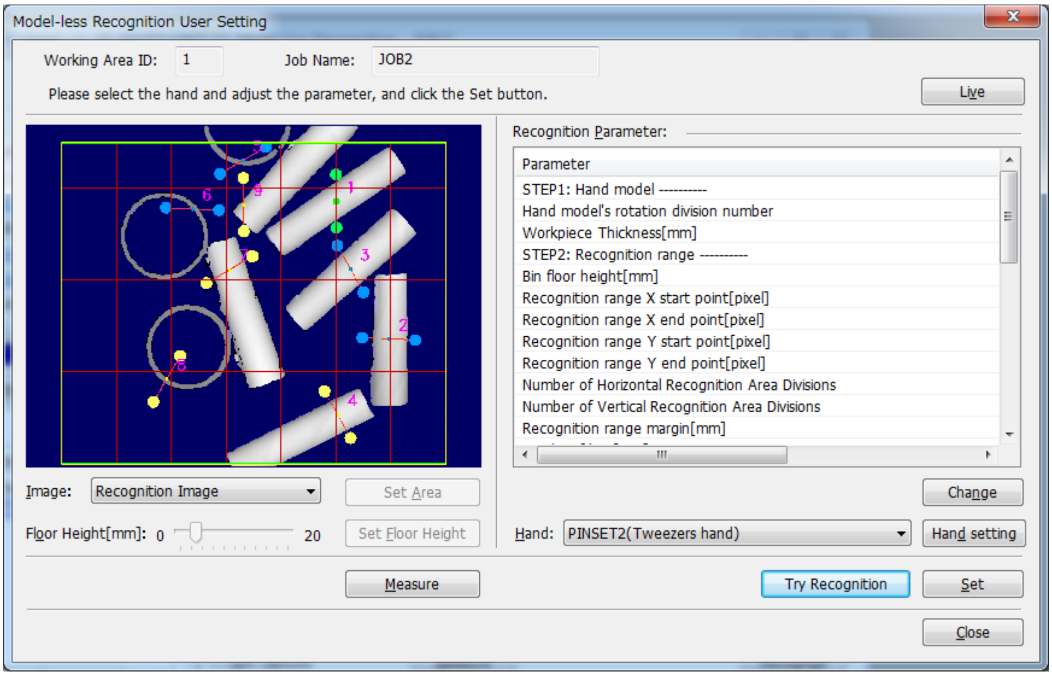


Fig. 7-91 User settings for model-less recognition

Table 7-20: Recognition parameters

Parameter	Unit	Description	Range	Default setting
STEP 1: Hand model				
Hand model's rotation division number Note 1 Note 2	-	Specifies the division number of 180 degrees. (Large: improved accuracy, small: increase in speed)	1 to 90	7
Workpiece Thickness	mm	Minimum height required to judge gaps as workpieces. The smaller the value, the greater the number of candidates, however, the possibility of misjudgment also increases.	0.1 to 100.0	3.0
STEP 2: Recognition range				
Bin floor height	mm	Distance that the floor is offset from the measurement surface. It is basically a fudge factor on the recognition side, saying don't start seriously looking for candidates unless they are x distance from the measurement surface (Refer to Fig. 7-92.)	0 to 255	10
Recognition range X start point Note 6	pixel	Distance from the left side of the screen to the X starting point. (origin located at the top left corner of the screen, right direction X+, lower direction Y+) (refer to Fig. 7-92.)	10 to 1260	100
Recognition range X end point Note 6	pixel	Distance from the left side of the screen to the X end point. (origin located at the top left corner of the screen, right direction X+, lower direction Y+) (refer to Fig. 7-92.)	20 to 1270	1180
Recognition range Y start point Note 6	pixel	Distance from the top of the screen to the Y starting point. (origin located at the top left corner of the screen, right direction X+, lower direction Y+) (refer to Fig. 7-92.)	10 to 940	50

Parameter	Unit	Description	Range	Default setting
Recognition range Y end point Note 6	pixel	Distance from the top of the screen to the Y end point. (20-950) default: 950 (origin located at the top left corner of the screen, right direction X+, lower direction Y+) (refer to Fig. 7-92.)	20 to 950	950
Number of Horizontal Recognition Area Divisions	-	Horizontal recognition area is divided into N number of equally sized segments (X direction) Small: Fast detection, Few candidates. Big: Slow detection, Many candidates.	2 to 7	3
Number of Vertical Recognition Area Divisions	-	Recognition range is divided by the specified number of divisions. (Y direction) Small: Fast detection, Few candidates. Big: Slow detection, Many candidates.	2 to 7	3
Recognition range margin	mm	Set the margin of the recognition range (refer to Fig. 7-93.)	-50 to 100	0.0
Height of box	mm	Set the height of the box (refer to Fig. 7-93.)	0 to 300	0.0
Threshold of the residual percentage against the full measurement volume Note 3 Note 4	%	If the workpiece residual amount ratio is smaller than the threshold, recognition operation is not performed.	0.0 to 100.0	10.0
STEP 3: Outline extraction				
Edge Identification sensitivity	-	Threshold of edge strength for segmentation.	1 to 1000	30
Circle Detection: Enable/Disable	-	Disabled: Normal setting to avoid the fragmentation of segments. Ex. Non-circular work, thin ring. Enabled: Activation of cutting out segments for easier recognition of the circular work with specified diameter.	0: Disabled 1: Enabled	0: Disabled
Circle Detection : Diameter	mm	Diameter of the circle for detection	10 to 150	30
STEP 4: Segment size				
Minimum pixel area per part	pixel	Minimum amount of pixels that must be grouped together to constitute a part. Aussumtion is the size of the part is converted to pixels by the following formula.	10 to 250000	30
Maximum Pixel Area per part	pixel	Maximum amount of pixels that when grouped together constitute a part. Aussumtion is the size of the part is converted to pixels by the following formula.	10 to 1228800	1228800
Smooth strength	-	The greater the value, the more noise is reduced.	-1: Original 0: No filter 1 to 4	4
STEP 5: Recognition processing				
Full search mode: Enable/Disable	-	0 - Disable: Search candidates at center of the segment. 1 - Enable: Search candidates at center of the segment and full region. This setting needs much more time, but enlarges the number of detection points.	0: Disabled 1: Enabled	1: Enabled
Image Scale factor Note 5	-	After the image is reduced to 1/n, it is processed. A low value increases accuracy but processes slower, and a high value has decreased accuracy with faster processing.	1 to 8	2

Parameter	Unit	Description	Range	Default setting
Main axis feature mode	-	Swith the main axis feature mode (length feature, angle estimate) (refer to Fig. 7-94.)	0: Disable 1: Length 2: Angle 3: Length + Angle	0
Minimum main axis length	mm	Check that the length of the main axis is greater than or equal to this threshold. The length of the main axis is calculated with ellipse (circumcircle) fitting (refer to Fig. 7-94.)	1 to 250	10
Maximum main axis length	mm	Check that the length of the main axis is less than or equal to this threshold. The length of the main axis is calculated with ellipse (circumcircle) fitting (refer to Fig. 7-94.)	10 to 1000	100
Minimum main axis ratio	%	Check that the ratio of minor axis to major axis is greater than or equal to this threshold. The major axis and minor axis are calculated with ellipse (circumcircle) fitting (refer to Fig. 7-94.)	0 to 100	0
Maximum main axis ratio	%	Check that the ratio of minor axis to major axis is less than or equal to this threshold. The major axis and minor axis are calculated with ellipse (circumcircle) fitting (refer to Fig. 7-94.)	0 to 100	100
Posture output mode	-	Change the output mode for the posture component. When you output component B, validate the main shaft characteristics (direction estimate) mode. Select RH type when the RV model hanging from the ceiling is used. 0: Camera coordinates (component C) 1: Robot coordinates (component C, RV type) 2: Robot coordinates (components B and C, RV type) 3: Robot coordinates (component C, RH type) 4: Robot coordinates (components B and C, RH type) 0: Posture in the camera coordinates system is output. 1 to 4: Posture in the robot coordinates system is output. Select 2 or 4 when the grip force for the normal direction of the object is expected. * Regarding the camera coordinates system, refer to Fig. 3-9. * The robot coordinates system is the base coordinates system.	0 to 4 * The details refer to the left column.	1
Recognized candidates output mode	-	Sort the order of the recognized candidates.	1: Graspabiity (descendling order) 2: Average Height (descending order) 21: Grasperbility x Average Heigh (descending order)	21

Note 1: Model-less recognition involves searching for gaps into which hand model claw can be inserted and flat surfaces to which suction pads can be attached, and returning this as the recognition result. When doing so, the search is performed while rotating the hand model, and therefore the resolution is specified.

Note 2: By entering a small value, the recognition time decreases, however, the accuracy of the hand model rotation angle drops, and the number of candidate grip positions decreases. By entering a large value, the recognition time increases, however, the accuracy of the hand model rotation angle improves, and the number of candidate grip positions increases. If using a tweezers hand or parallel hand, if the rotation angle accuracy drops, there is a possibility that the workpiece may rotate when gripped. When using a suction hand with a pad of the shape other than a perfect circle such as an ellipse, air may leak.

Note 3: If the hand claw or suction pad interferes with the measurement stand or bottom of the parts supply box because of misrecognition resulting from measurement data for the measurement stand or bottom of the parts supply box, or due to noise, interference can be avoided by entering a large value. However, if the workpiece residual amount becomes lower than the specified value, recognition is not performed even if there are workpieces remaining, and therefore the number of workpieces that can be taken out drops.

Note 4: The current workpiece residual amount can be obtained with the status variable "M_V3Dat1(n,1)".

Note 5: By entering a small value, the recognition time increases, however, the recognition accuracy improves. By entering a large value, the recognition time decreases, however, the recognition accuracy drops.

Note 6: As the recognition range widens, the recognition time gets longer.
Upper Left: Origin, Right direction: +X, Down direction: +Y.

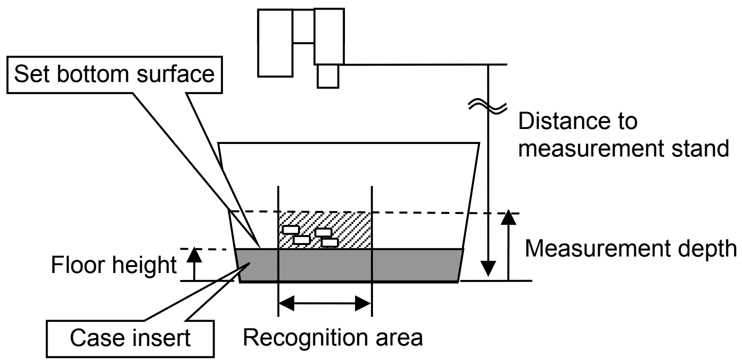


Fig. 7-92 Definition of the bin floor height and the recognition domain

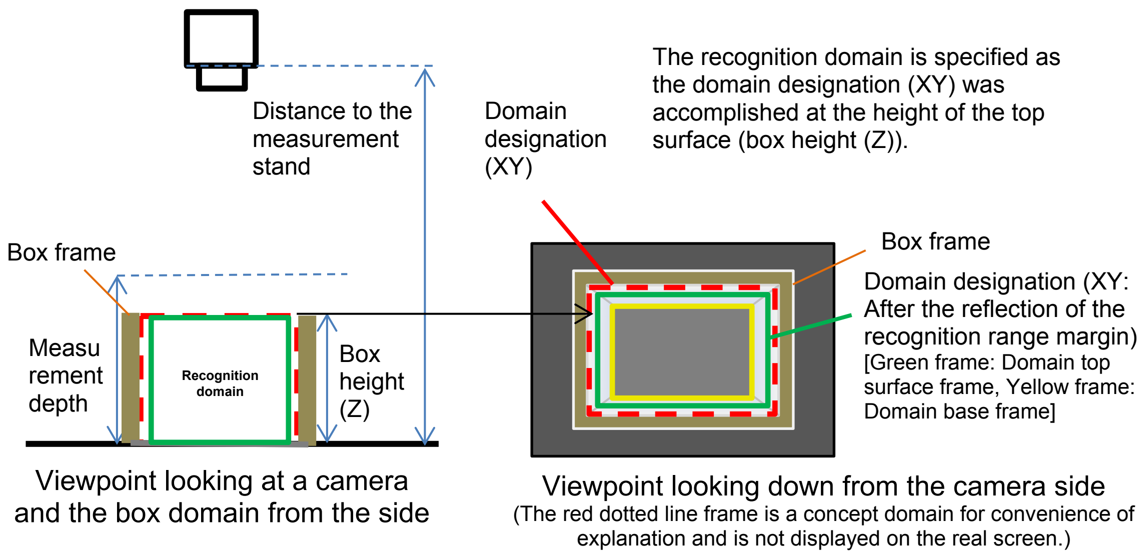


Fig. 7-93 Explanatory drawing for the recognition domain (recognition range margin, height of box)

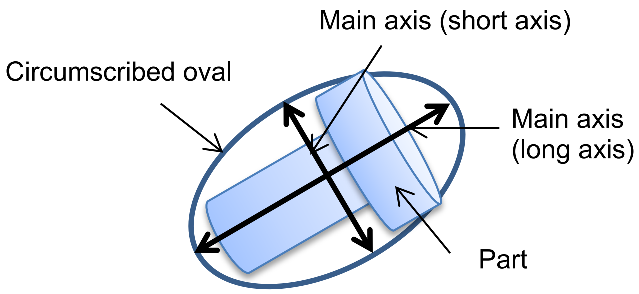


Fig. 7-94 Definition for the main axis feature mode

By clicking the [Try Recognition] button, recognition is performed based on the set conditions and the result is displayed in the image on the left. In order to confirm the process until the recognition results (each STEP of the recognition parameters), the displayed images (images during the recognition process) can be changed by selecting the type of image among the images (I): pull-down. The effect of each recognition parameter can be confirmed by the image at each step. Table 7-21 shows a list of each STEP of the recognition parameters and the corresponding images, while Fig. 7-95 illustrates an example of an indication image.

Table 7-21: Each STEP for the recognition parameters and the corresponding images

STEP	Setting	Corresponding image
1	Hand model	-
2	Recognition range	Floor removal image
3	Outline extraction	Edge detection image
4	Segment size	Labeling image
5	Recognition processing	Recognition image

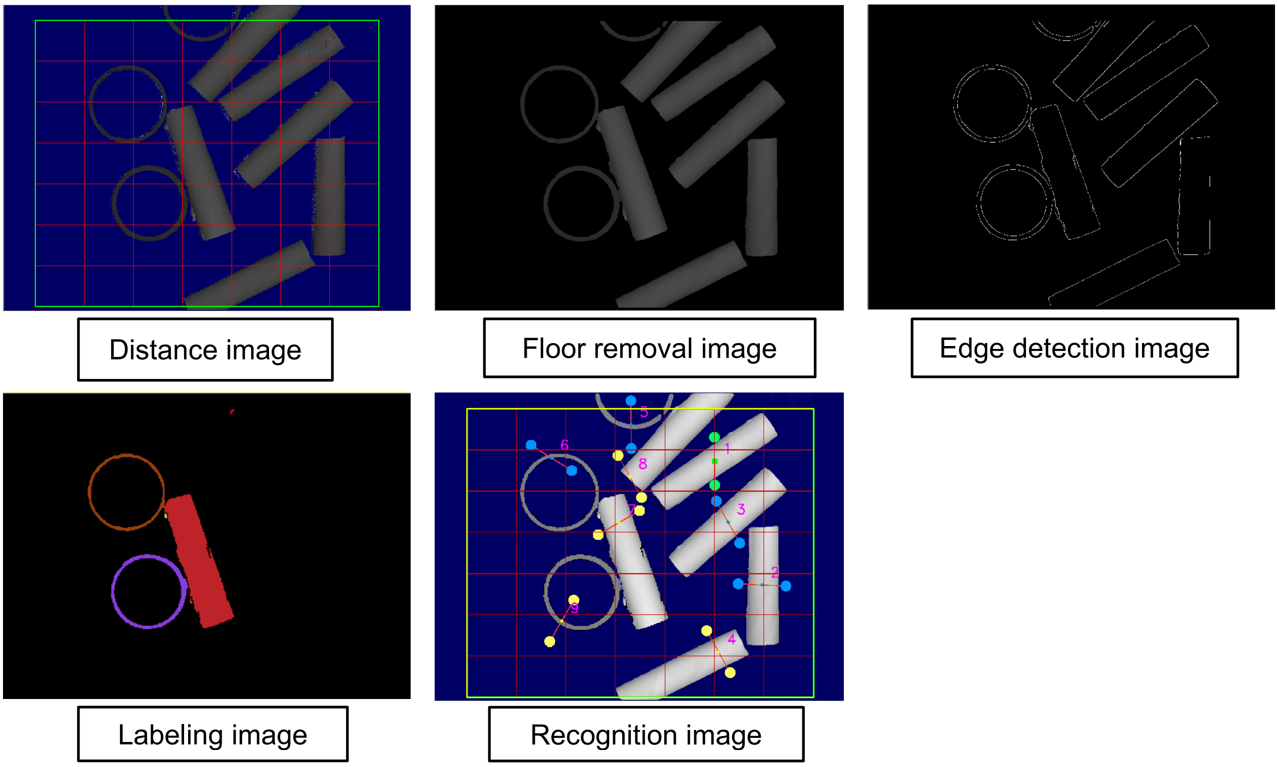


Fig. 7-95 Types of display images

If there are no problems with the recognition time or recognition result, click the [Set] button and then close the Model-less recognition user settings screen.

Checking the recognition results
Change the position of the workpiece in the measurement range, or increase the number of workpieces. Click the [Measure] button to perform measurement, and then click the [Recognize] button to perform recognition.
Recognition result with the highest score is drawn in green, the recognized position values are displayed in the Result field. Other color meanings: Yellow: Results from full search, Blue: Results from segment search. By clicking the [Display list] button, other results can also be viewed. Please note that the results are displayed in the list in order from the higher score.
Although the parting line (red line) of the recognition results in the setting window may not be displayed, using it has no effect. To confirm parting lines which are not displayed, click the image of the recognition results and then display the enlarged image screen.

The recognition results are the hand coordinate system position and posture viewed from the camera coordinate system (see Fig. 3-9).

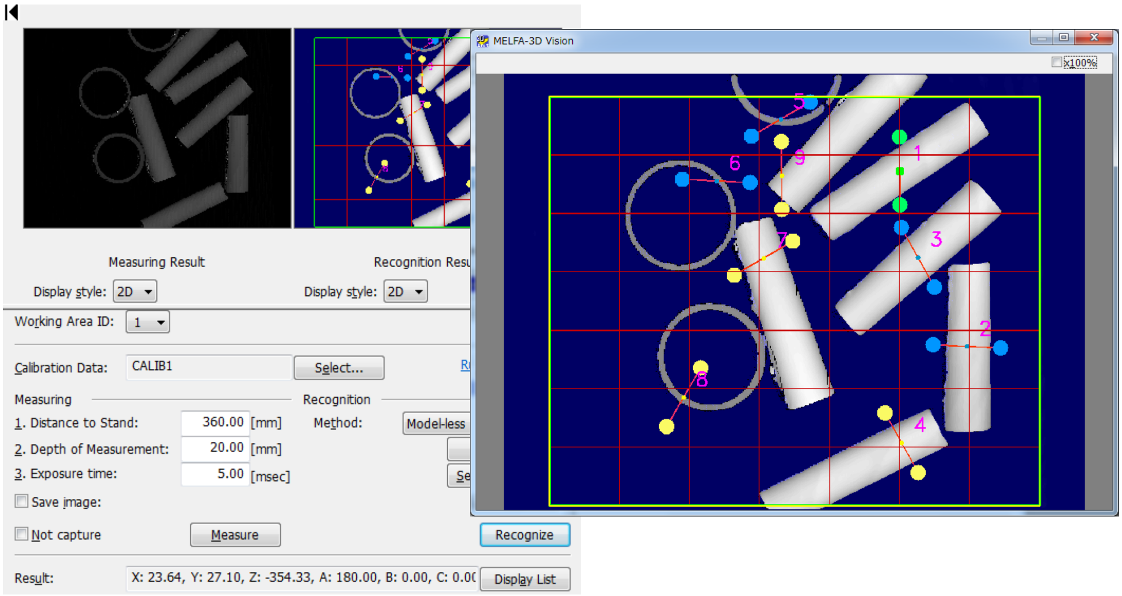
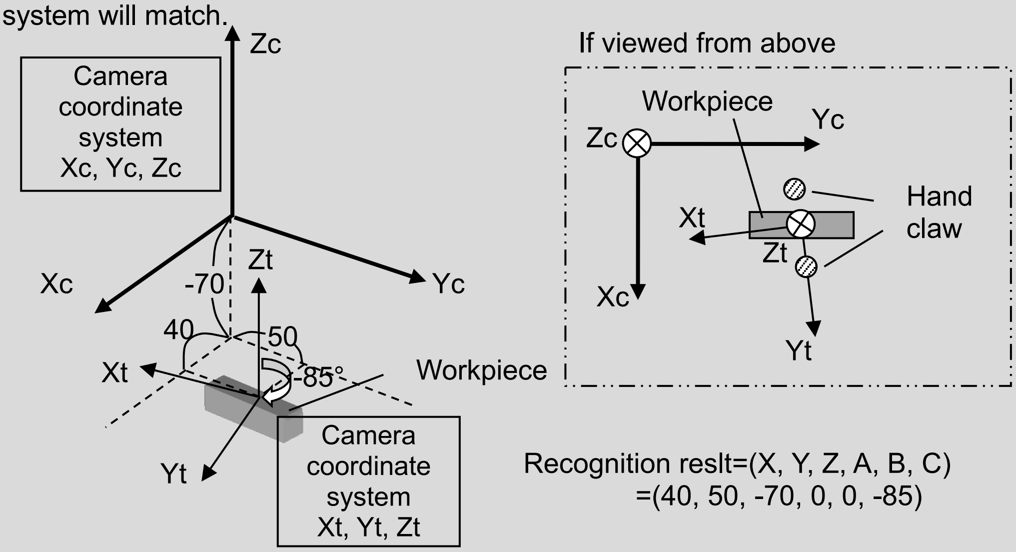


Fig. 7-96 Confirmation of the recognition results

◇◆◇Recognition results◇◆◇
The position at the top of the workpiece surface is returned for the recognition result Z component. Furthermore, the C component is the rotation angle (-90° ≤ C < 90°) around the hand coordinate system Z-axis in the camera coordinate system. Please note that if X, Y, Z, A, B, and C in the recognition results are all 0, the camera coordinate system and the hand coordinate system will match.



If there are no problems with the results, click the [Execute the job being edited] link to proceed to job execution.

(2) Model matching recognition

Model matching recognition is a method used to search for a shape similar to shape information created from workpiece 3D-CAD model data. The three-dimensional orientation of workpieces can be detected, and the output position information contains the **X, Y, Z, A, B, and C components.** This is the recognition position, and differs from the grip position. Consequently, it is necessary to calculate in advance the "Correction vector" to correct the deviation between the recognition position and the grip position as shown in Fig. 7-97. By calculating the grip position from the recognition position using the correction vector, workpieces can be gripped.

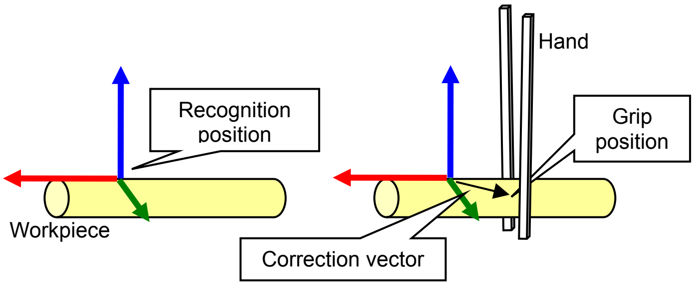


Fig. 7-97 Difference between recognition position and grip position

3D-CAD model preparation

Pay attention to the following when creating 3D-CAD models.

- Create so that the origin is near the center of the CAD model.
- Use the CAD coordinate system XY plane as the floor surface, and arrange the workpiece position to get the **most** stable posture.

◇◆◇3D-CAD model origin◇◆◇

If manipulating the 3D-CAD model viewpoint on RT ToolBox2, the viewpoint can be changed with the **model origin as the rotational center**. Consequently, the closer the model center and CAD origin are to one another, the easier the operability when rotating.

◇◆◇Stable posture◇◆◇

This refers to a posture to enable self-standing of the workpiece in a stationary state without the need for any support.

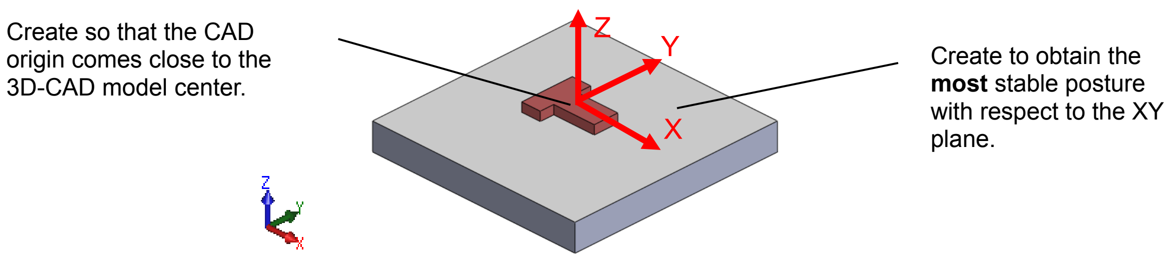


Fig. 7-98 3D-CAD model creation example

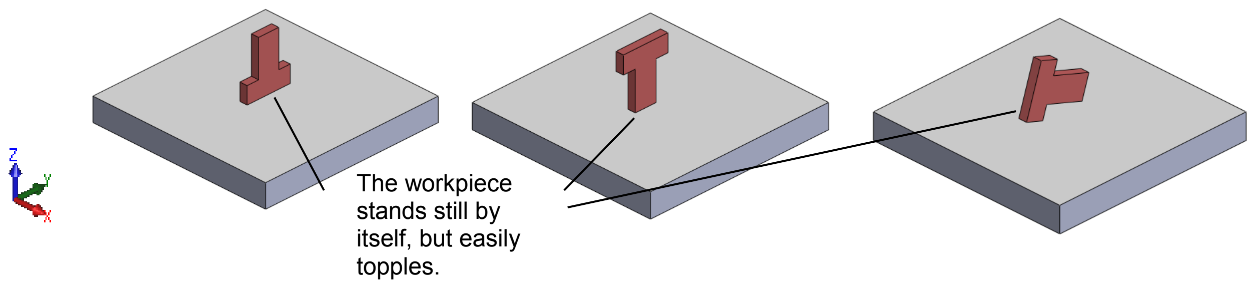


Fig. 7-99 Example of other unstable postures

Selecting the recognition method

Select "Model matching" from the drop-down menu.

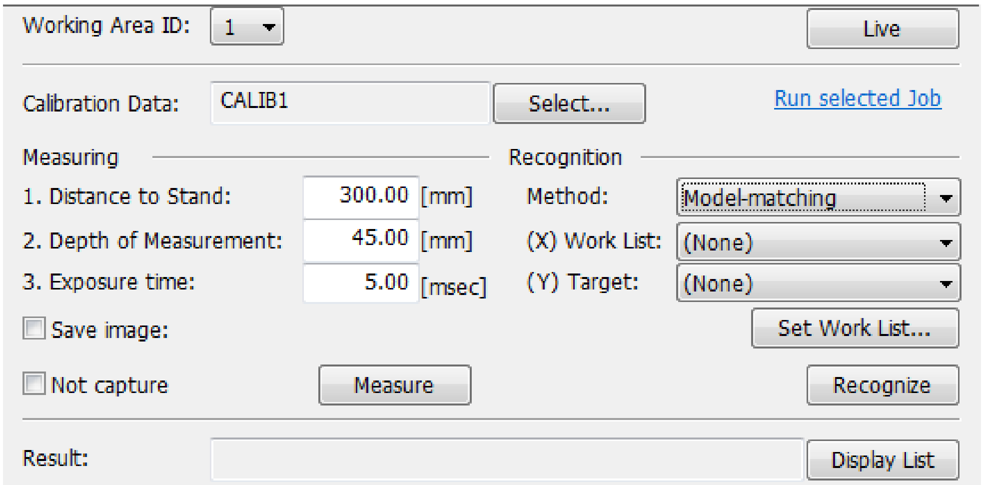
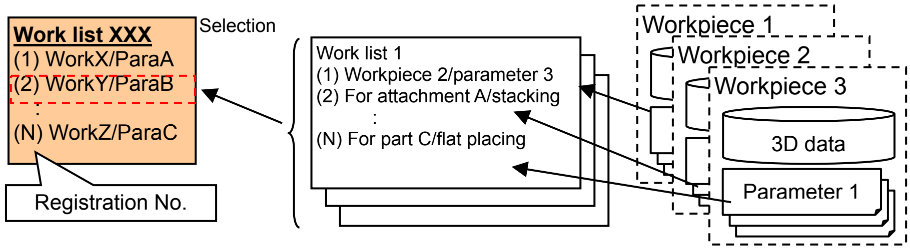


Fig. 7-100 Selection of the recognition method (model matching recognition)

The table below describes the items, workpiece list and recognition target, that appear when the model matching is selected.

Table 7-22: Workpiece list and recognition target

Item name	Description
Work List	A list of combinations of the registered workpieces and parameters to be used. In a job, select the combinations to be used in the work list. In the robot program, the numbers registered in the work list are specified. 
Target	Target of the recognition test which is performed when the [Recognize] button is pressed. As well as the registration numbers, workpiece names and parameter names are also displayed.
Set Work List button	Opens the Create workpiece list screen. The following tasks can be carried out at the Create workpiece list screen. (1) Conversion to a dedicated data format from 3D-CAD data (2) Recognition using arbitrary parameter values (3) Creation of workpiece lists from registered workpieces/parameters

Workpiece registration

Click the [Set Work List] button to open the Work list settings screen, and then click the [Register Work] button in the screen. Then, by clicking the workpiece field [Add] button in the [Register Work] screen, the [Add Work] screen appears.

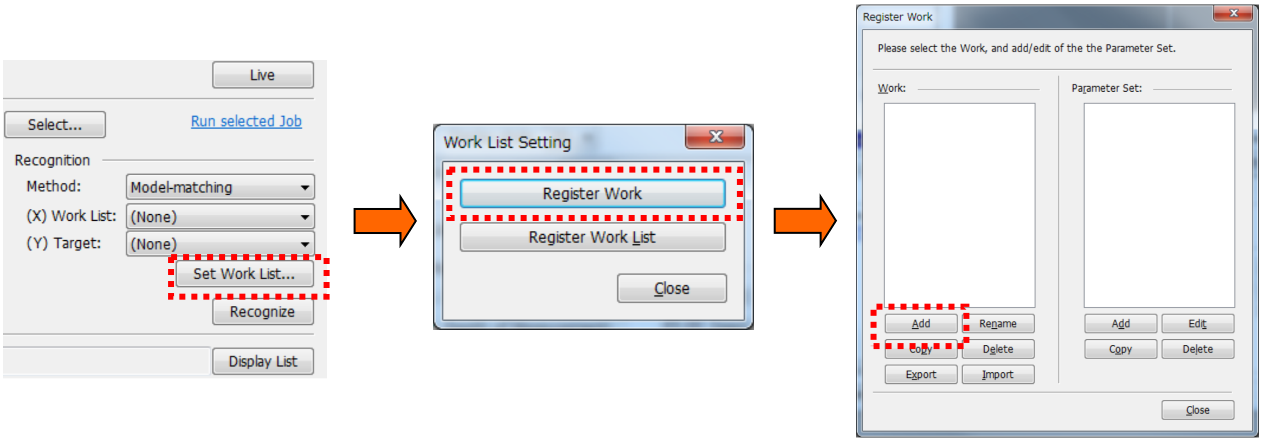


Fig. 7-101 Workpiece list settings and workpiece registration

Perform the following four steps to register workpieces at the Workpiece addition screen.

(a) 3D-CAD model selection
Click the model file selection [Select] button in the Workpiece addition screen, and then select the 3D-CAD data (STL format Note 1 or OBJ format) to be used. By selecting the 3D-CAD model, data is converted to a dedicated format and edge detection is performed in the control unit. After approximately 10 to 30 seconds, the images before and after processing are updated.

Note 1: Compatible with both binary and text formats.

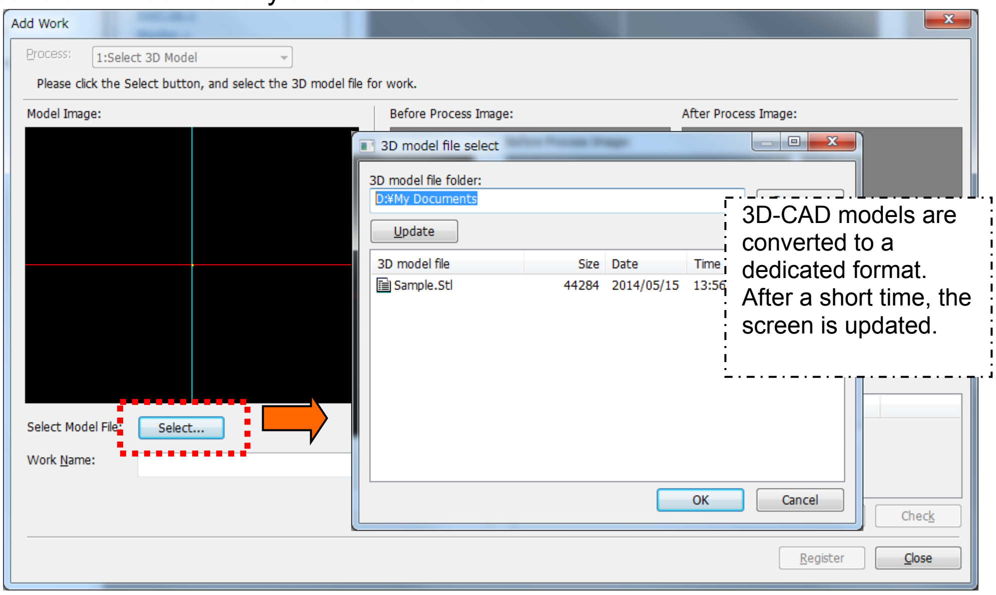


Fig. 7-102 Workpiece addition

(b) Edge detection
Select "2: Edge detection" from the processing step combo box. The image after edge detection from the 3D-CAD model appears in the image after processing.

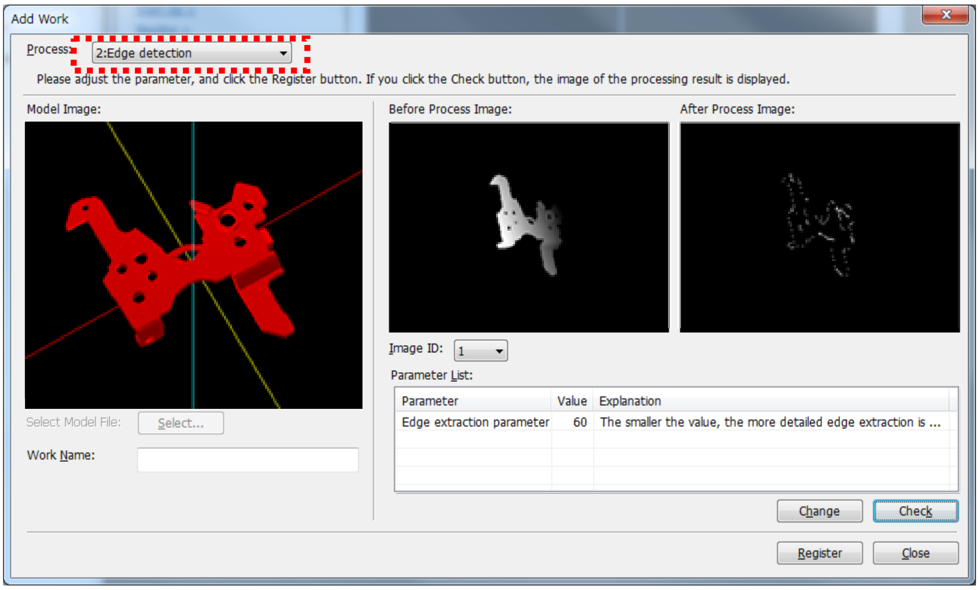


Fig. 7-103 Edge detection

Table 7-23: Parameter for edge detection

Parameter	Unit	Description	Range	Default setting
Edge extraction parameter	-	The smaller the value, the more detailed edge extraction is performed, however, the speed drops.	1 to 500	60

By clicking images before or after processing, an enlarged image screen appears in a pop-up window. The window can be closed by clicking the enlarged image screen.

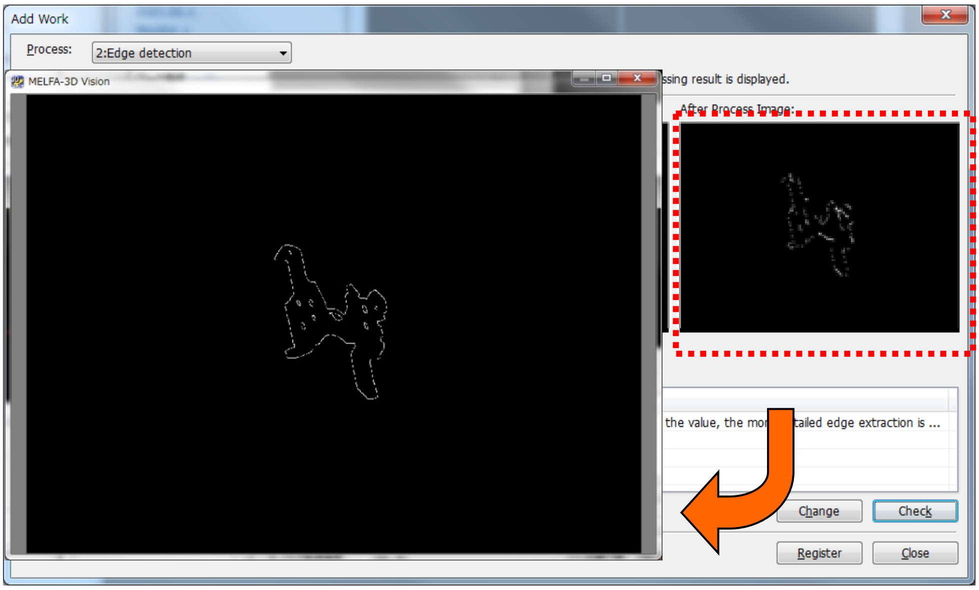


Fig. 7-104 Enlarged image

Check the enlarged image screen for the image after processing to ensure that edges are detected as described in Table 7-24 .

Table 7-24: Check items for edge detection

No.	Check item	Remedy
1	Is the edge detected on a flat surface?	If the edge is detected on a flat surface, increase the "Edge extraction parameter" to ensure that edges are not detected on a flat surface.
2	Is it possible to imagine the shape of the model image before processing from the displayed image?	If unable to imagine the shape of the model image, reduce the "Edge extraction parameter" so that the shape can be imagined from the edge.

By selecting the parameter in the parameter list and clicking the [Change] button, the parameter value can be changed.

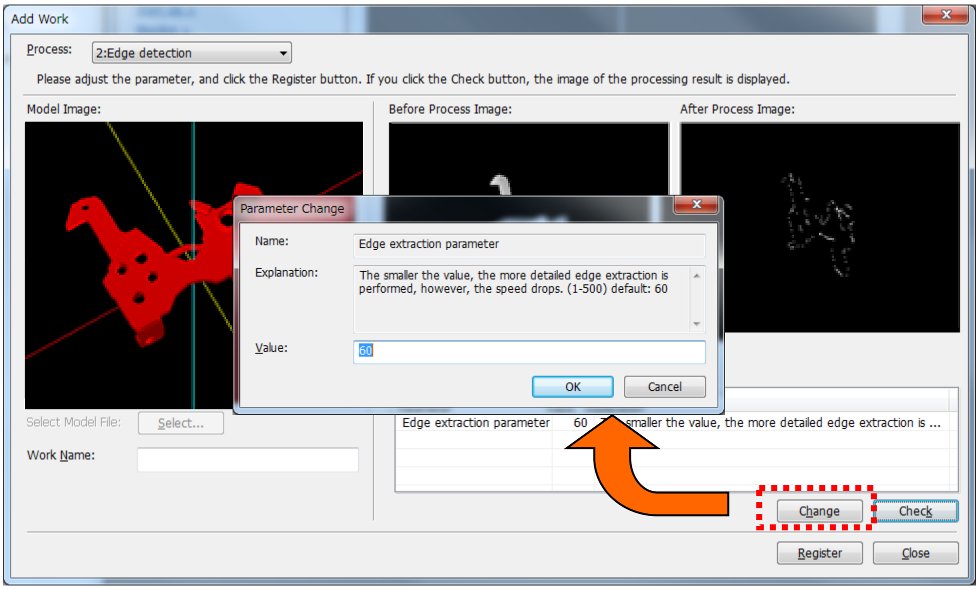


Fig. 7-105 Parameter change

By clicking the [Check] button after changing the parameter value, edge detection processing is performed again. After a short while, the images before and after processing are updated.

By changing the [Image ID] in the Workpiece addition screen, it is possible to display images before and after processing from eight viewpoints. Ensure that edge detection satisfies Table 7-24 also for the remaining seven viewpoints, and if not, adjust the parameter.

(c) Sampling of point

Select "3: Sampling of point" from the processing step combo box. The image in which points are sampled from straight lines is displayed in the image after processing. Please note that sampled points appear in red.

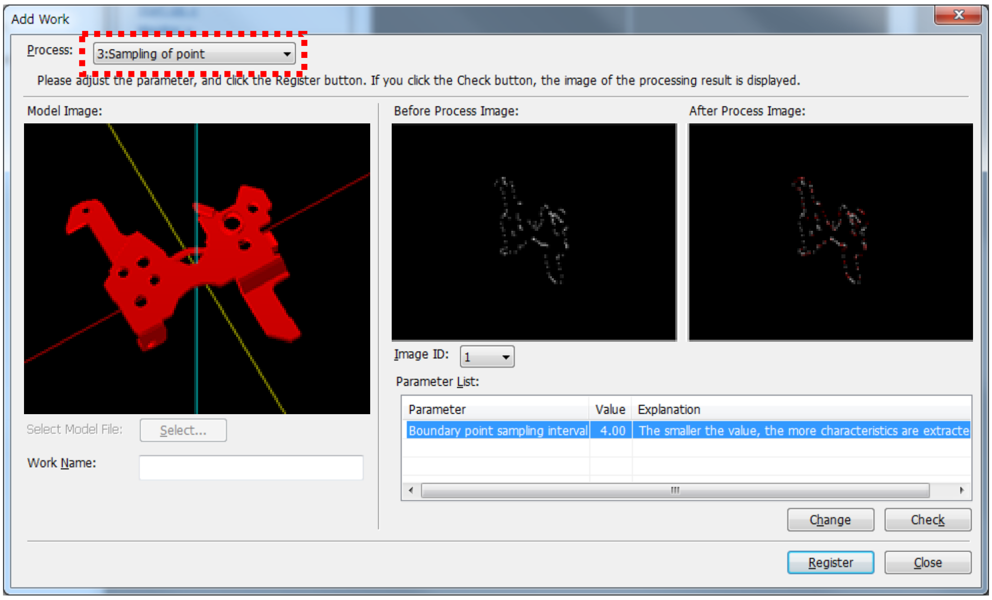


Fig. 7-106 Sampling of point

Table 7-25 Parameter for point sampling

Parameter	Unit	Description	Range	Default setting
Boundary point sampling interval	-	The smaller the value, the more characteristics are extracted, however, the speed drops.	1.0 to 100.0	4.0

Check the enlarged image screen for the image after processing to ensure that points are sampled.

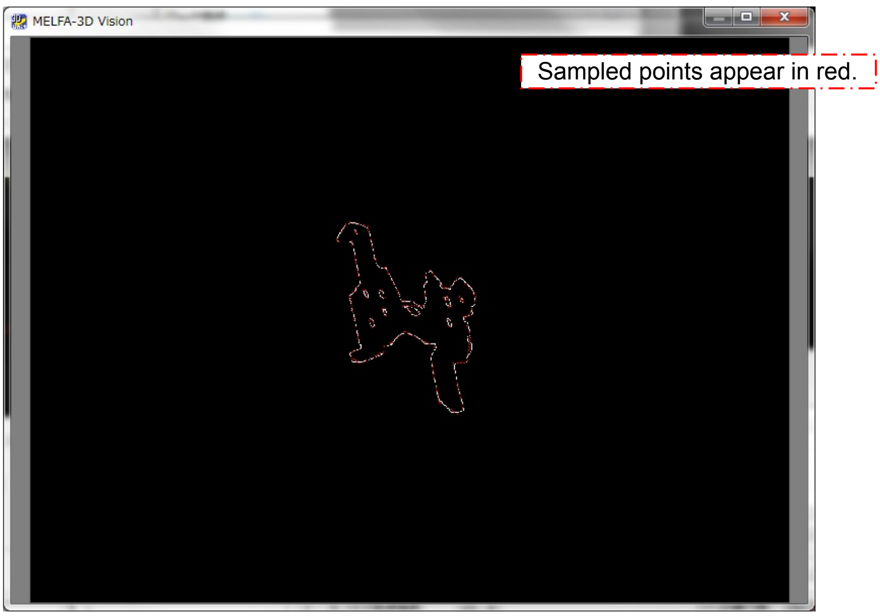


Fig. 7-107 Successful example for sampling of point

Ensure that points are sampled also in the remaining seven viewpoints, and if not, adjust the parameter.

(d) Tangent line detection
Select "4: Tangent line detection" from the processing step combo box. The image in which tangent lines are detected from the edge is displayed in the image after processing. Please note that detected tangent lines appear in green.

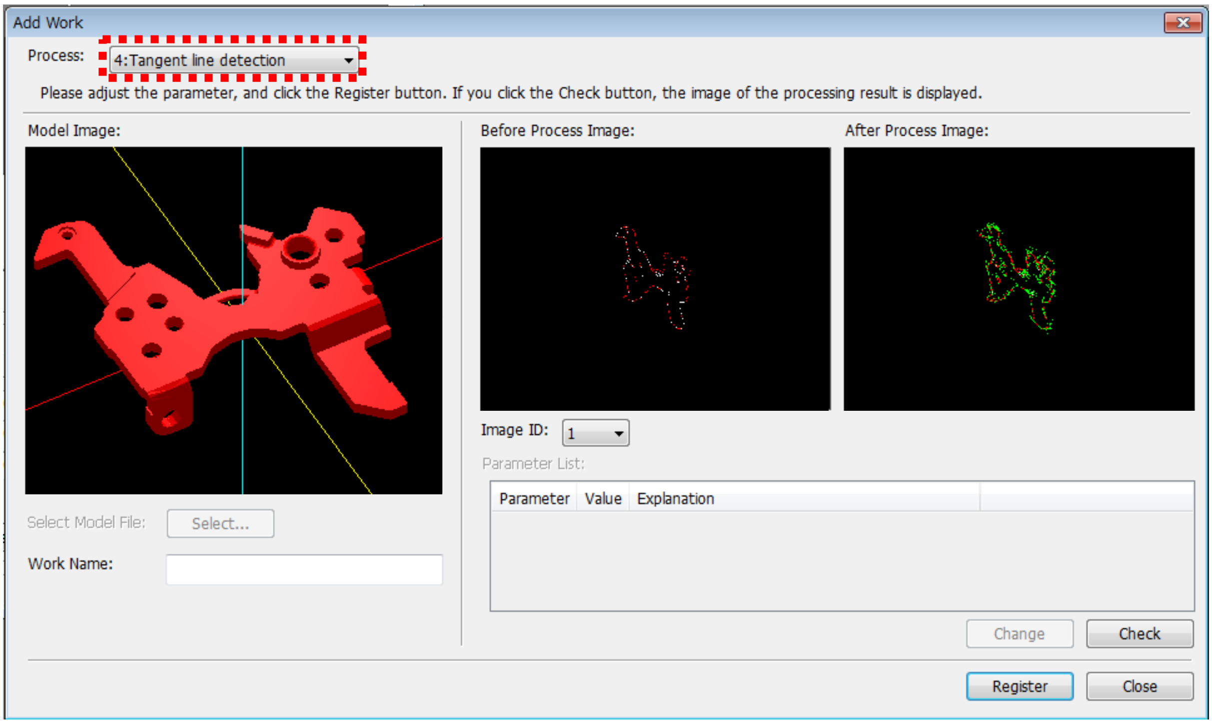


Fig. 7-108 Tangent line detection

Check the enlarged image screen for the image after processing to ensure that straight lines are detected as in Fig. 7-109.

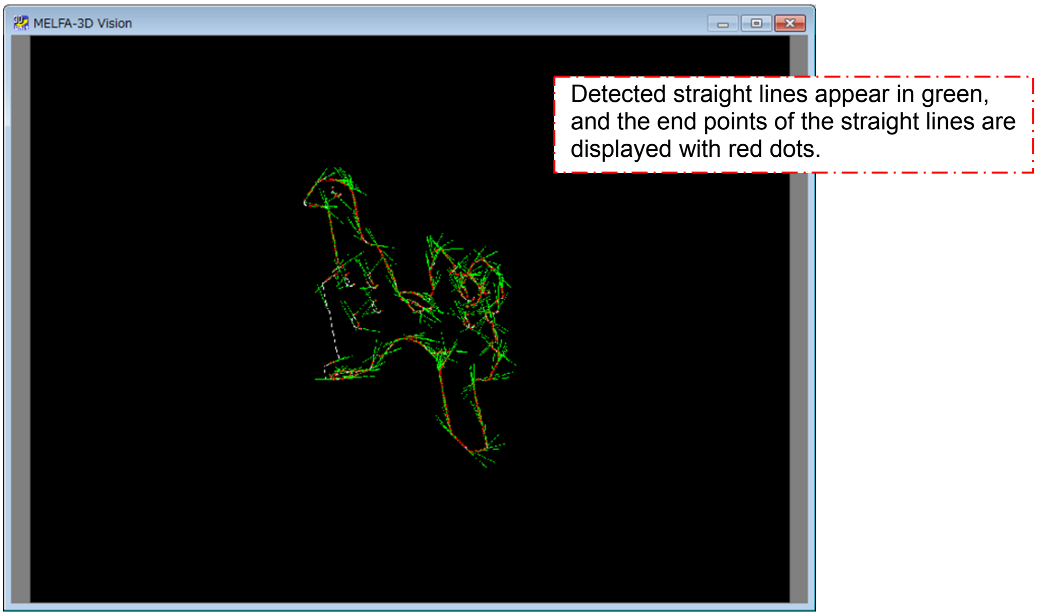


Fig. 7-109 Straight line successful example

When adjustment is completed, enter the workpiece name Note 1, and then click the [Register] button. It is necessary to wait a short while until this process is completed. Note 2

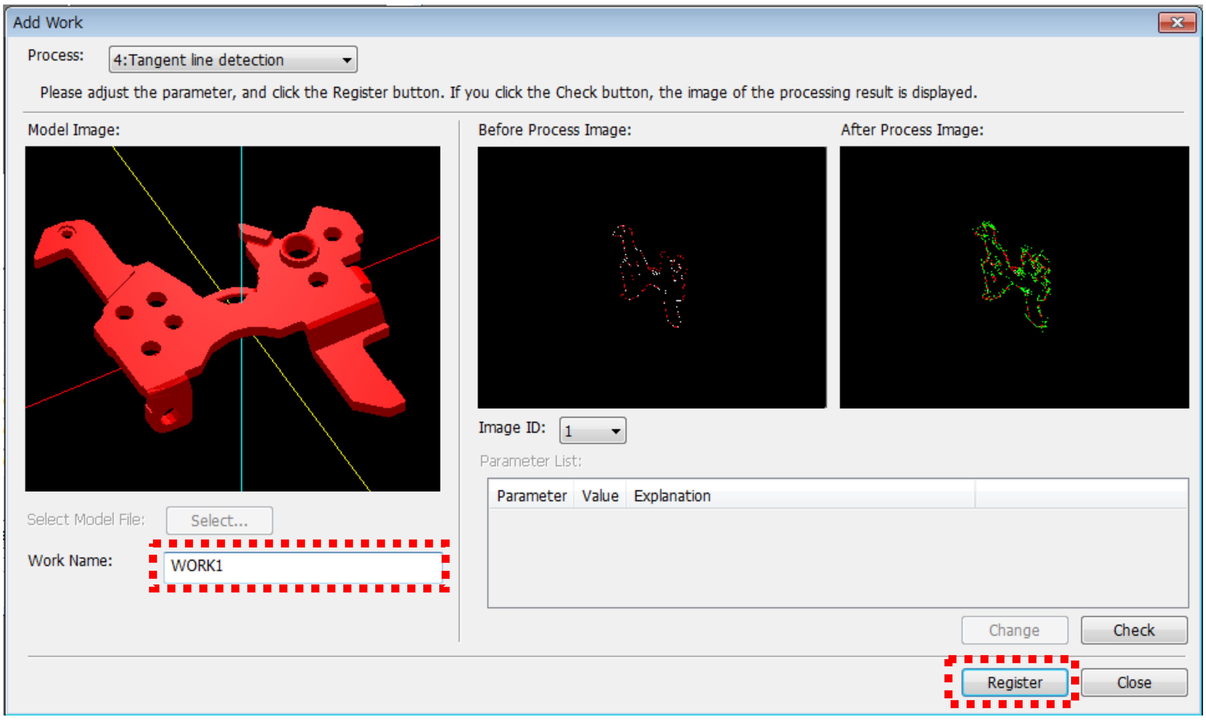


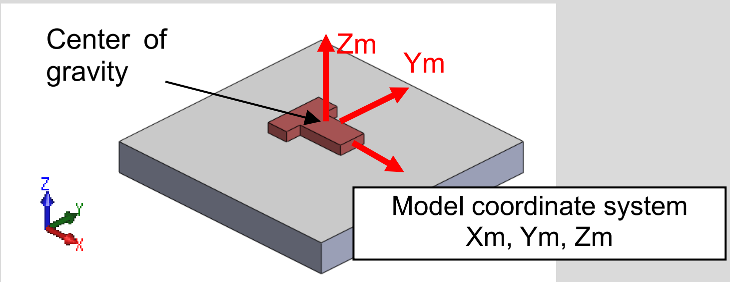
Fig. 7-110 Registration of workpiece

Note 1: Up to 32 single-byte alphanumeric characters. However, use alphabet characters only for the leading character.

Note 2: In the event registration takes time, the processing time can be shortened by increasing the value of "Boundary point sampling interval". However, the recognition rate may decrease if the value of this parameter is large.

◇◆◇Model coordinate system◇◆◇

When registering workpieces, the model coordinate system is set for the workpiece. The origin is the workpiece center of gravity, and the X-, Y-, and Z-axis directions match the CAD data coordinate system.



Exporting, importing model matching data
Model matching data (workpiece registration data and parameter set) for registered workpieces can be exported and imported. For exporting, click the [Export] button to display a Save model matching data screen, and save the data with an arbitrary name.

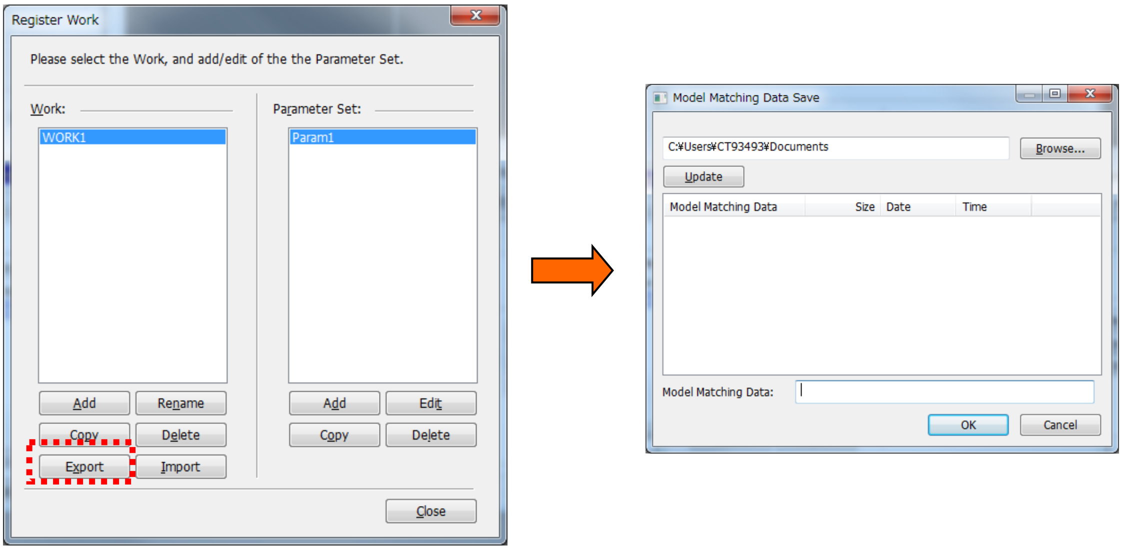


Fig. 7-111 Parameter set editing

For importing, click the [Import] button to display a Select model matching data screen, and then select the workpiece data to be imported.

Parameter set registration
For registration of the parameter set, set recognition parameters used when recognizing workpieces registered from measured images.

By clicking the [Add] button below the parameter set list at the Workpiece registration screen, a screen for entering the parameter set name appears. Enter an arbitrary name [Note 1] and click the [OK] button.

Note 1: Up to 32 single-byte alphanumeric characters

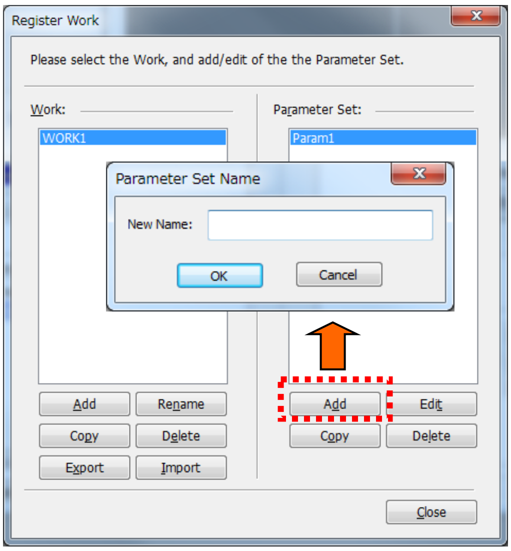


Fig. 7-112 Parameter set addition

Select the name of the added parameter set and click the [Edit] button.

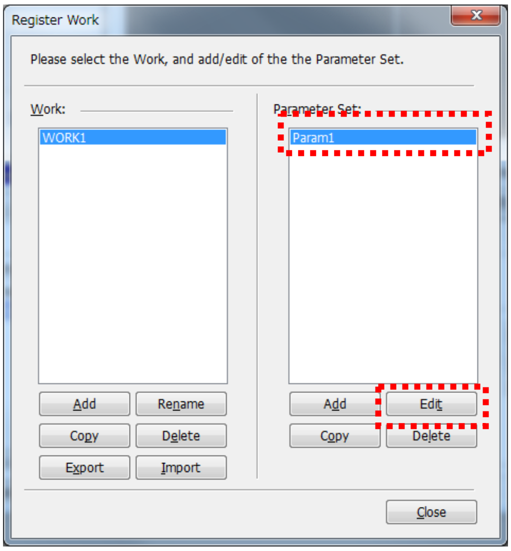


Fig. 7-113 Parameter set editing

(a) Distance image → edge detection

The image in which straight lines are detected from the edge is displayed in the image after processing. This processing will take a little time. Wait a short while until recognition images are updated.

When the recognition image is displayed, select "After process" option to change the image display, and display the image for which edges were detected.

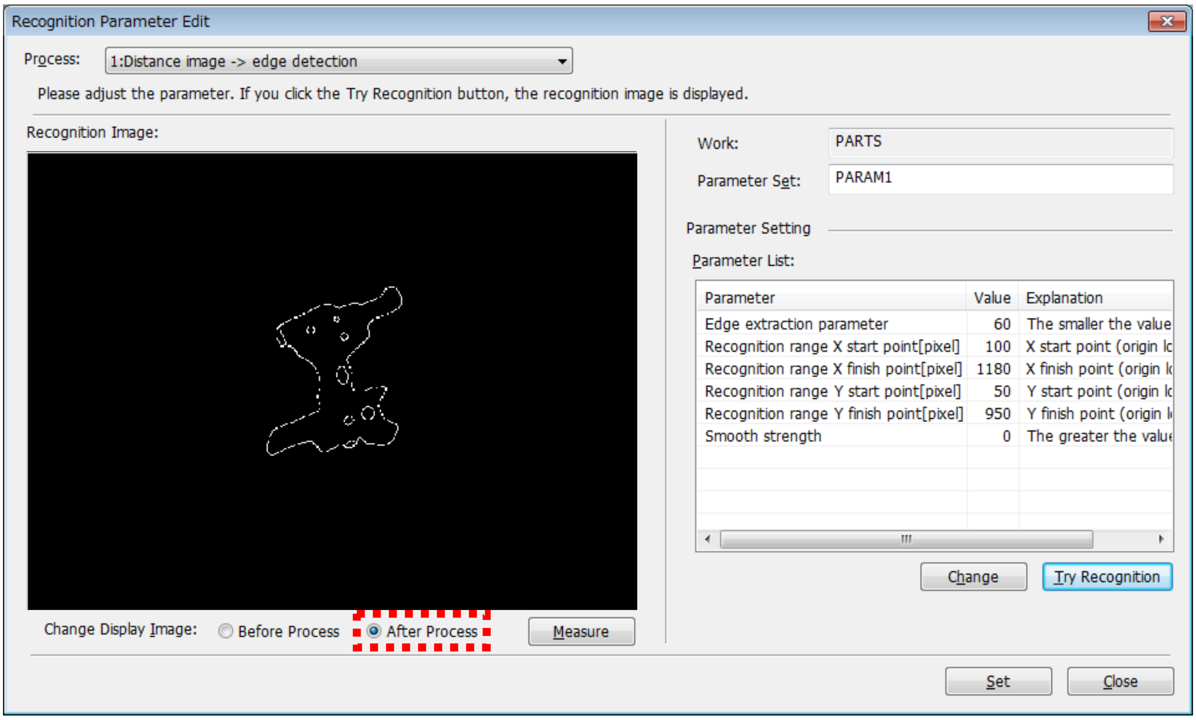


Fig. 7-114 Edge detection

Table 7-26: Parameter edge detection for recognition

Parameter	Unit	Description	Range	Default setting
Edge extraction parameter	-	The smaller the value, the more detailed edge extraction is performed, however, the speed drops.	1 to 500	60
Recognition range X start point Note 6	pixel	X start point (origin located at the top left corner of the screen, right direction X+, lower direction Y+)	0 to 1270	100

Recognition range X finish point Note 6	pixel	X finish point (origin located at the top left corner of the screen, right direction X+, lower direction Y+)	0 to 1279	1180
Recognition range Y start point Note 6	pixel	Y start point (origin located at the top left corner of the screen, right direction X+, lower direction Y+)	0 to 950	50
Recognition range Y finish point Note 6	pixel	Y finish point (origin located at the top left corner of the screen, right direction X+, lower direction Y+)	0 to 959	950
Smooth strength	-	The greater the value, the more noise is reduced.	0: No filter 1 to 4	0

By clicking the recognition image screen, an enlarged image screen appears in a pop-up window. The window can be closed by clicking the enlarged image screen.

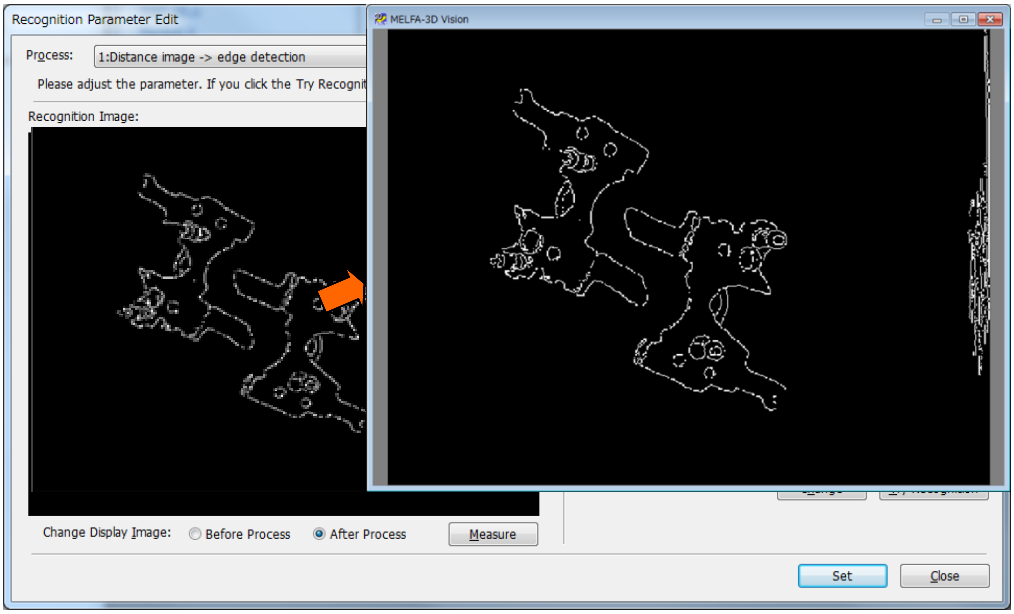


Fig. 7-115 Enlarged image

Check the enlarged image screen for the recognition image after processing to ensure that edges are detected as in Table 7-27.

Table 7-27: Check items for edge detection

No.	Check item	Remedy
1	Is the edge detected on a flat surface?	If the edge is detected on a flat surface, increase the "Edge extraction parameter" to ensure that edges are not detected on a flat surface.
2	Is it possible to imagine the shape of the model image before processing from the displayed edge?	If unable to imagine the shape of the model image, reduce the "Edge extraction parameter" so that the shape can be imagined from the edge.

By selecting the parameter in the parameter list and clicking the [Change] button, the parameter value can be changed.

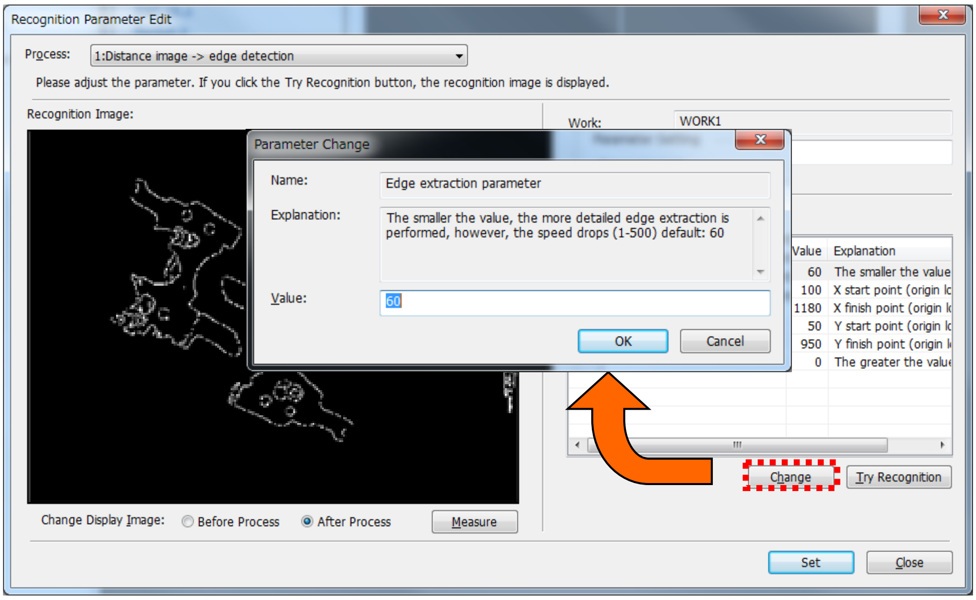


Fig.7-116 Recognition parameter change

By clicking the [Try Recognition] button after changing the parameter value, edge detection processing is performed again. This processing will take a little time. Wait a short while until recognition images are updated.

(b) Edge image → Point group sampling for recognition

Select "2: Edge image → Point group sampling for recognition" from the processing step combo box. The image in which points are sampled from edge image is displayed as the recognition image after processing.

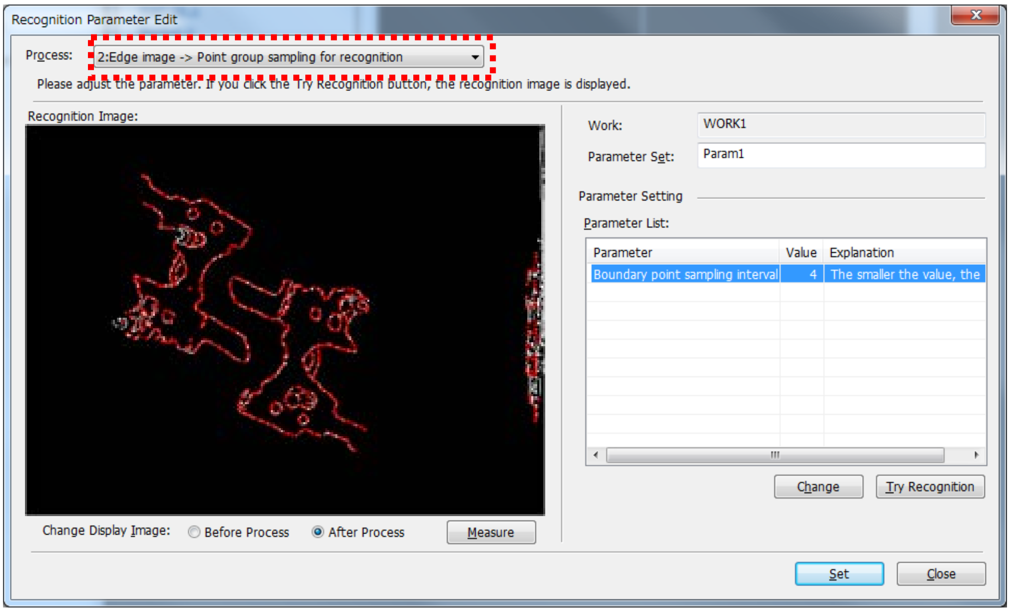


Fig. 7-117 Point group sampling for recognition

Table 7-28: Parameter of point group sampling for recognition

Parameter	Unit	Description	Range	Default setting
Boundary point sampling interval	-	The smaller the value, the more characteristics are extracted, however, the speed drops.	1 to 100	4

Check the enlarged image screen for the image after processing to ensure that points are sampled.

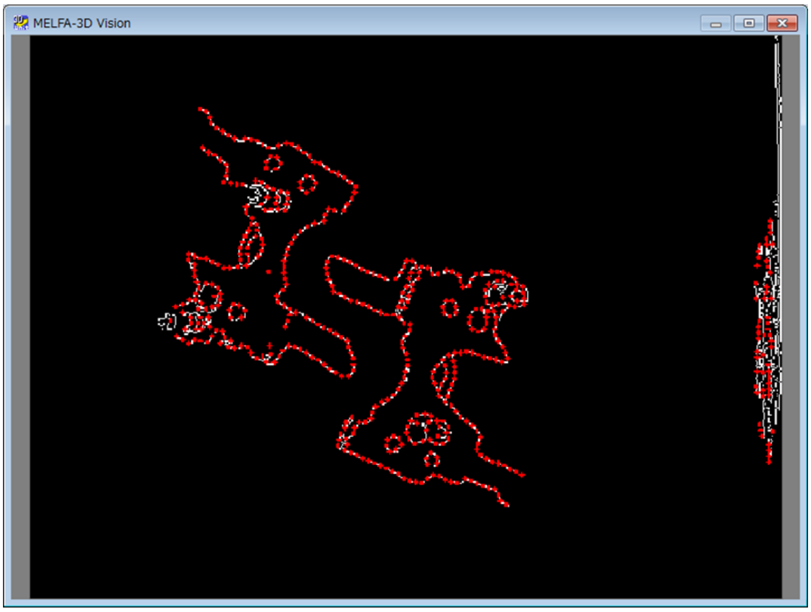


Fig. 7-118 Point sampling successful example

(c) Point group →Tangent line detection

Select "3: Point group →Tangent line detection" from the processing step combo box. The image in which tangent lines are detected from the edge point image appears in the recognition image after processing.

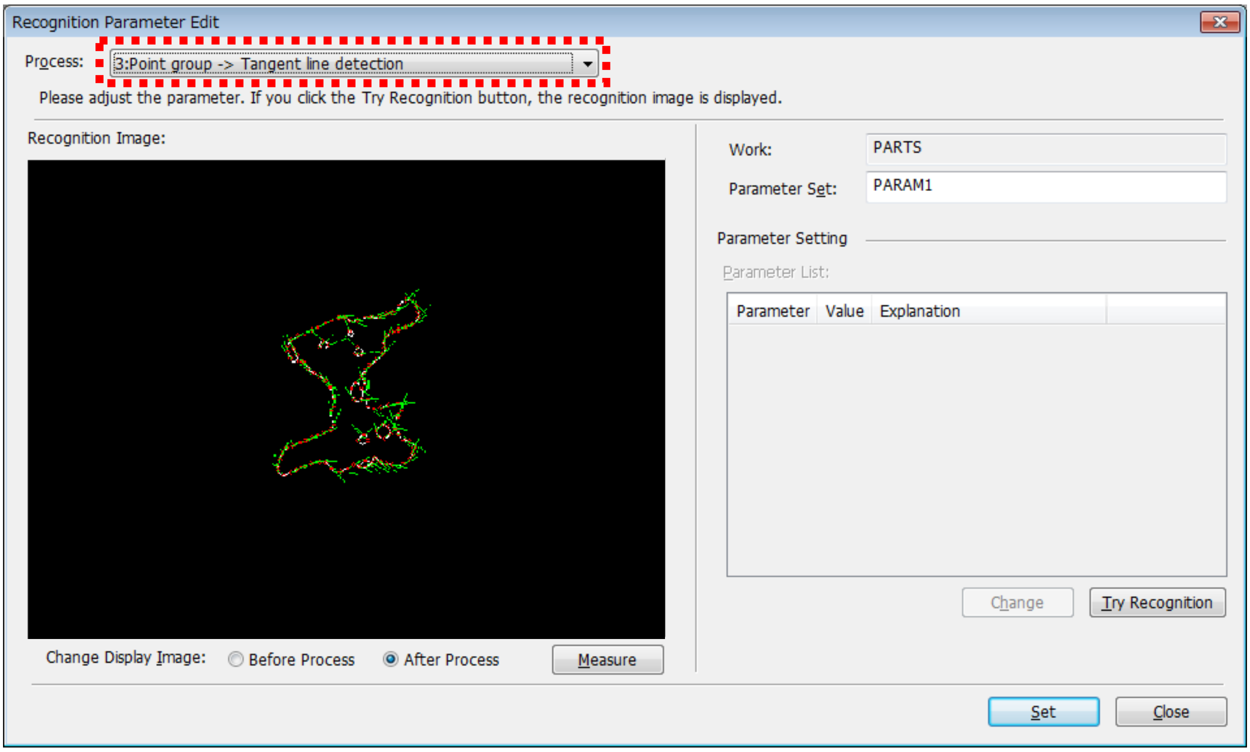


Fig. 7-119 Tangent line detection

While displaying the enlarged image screen of the recognition image, confirm that a straight line is detected as in Table 7-29.

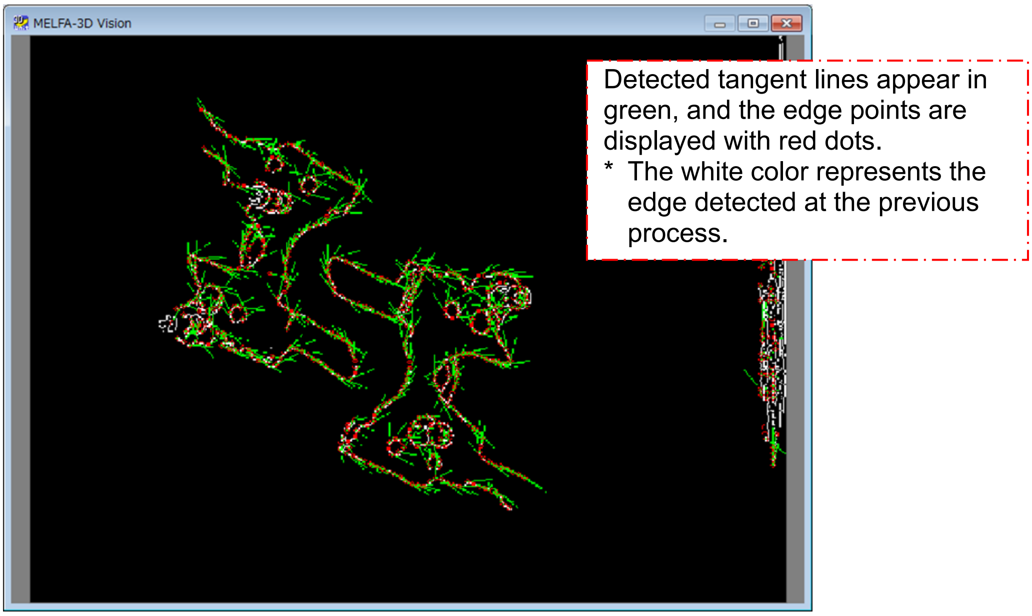


Fig. 7-120 Successful example of detected tangent lines

Table 7-29: Items to be confirmed during tangent line detection

No.	Check item	Remedy
1	Is there a significant deviation in the position of the white and green edges?	If so, there is a possibility that XY calibration may have been unsuccessful. Perform XY calibration again.

(d) Recognition processing
Select "4: Recognition processing" from the processing step combo box. The result of recognition processing is displayed as the recognition image after processing. The 3D-CAD model displayed in green is the recognition result.

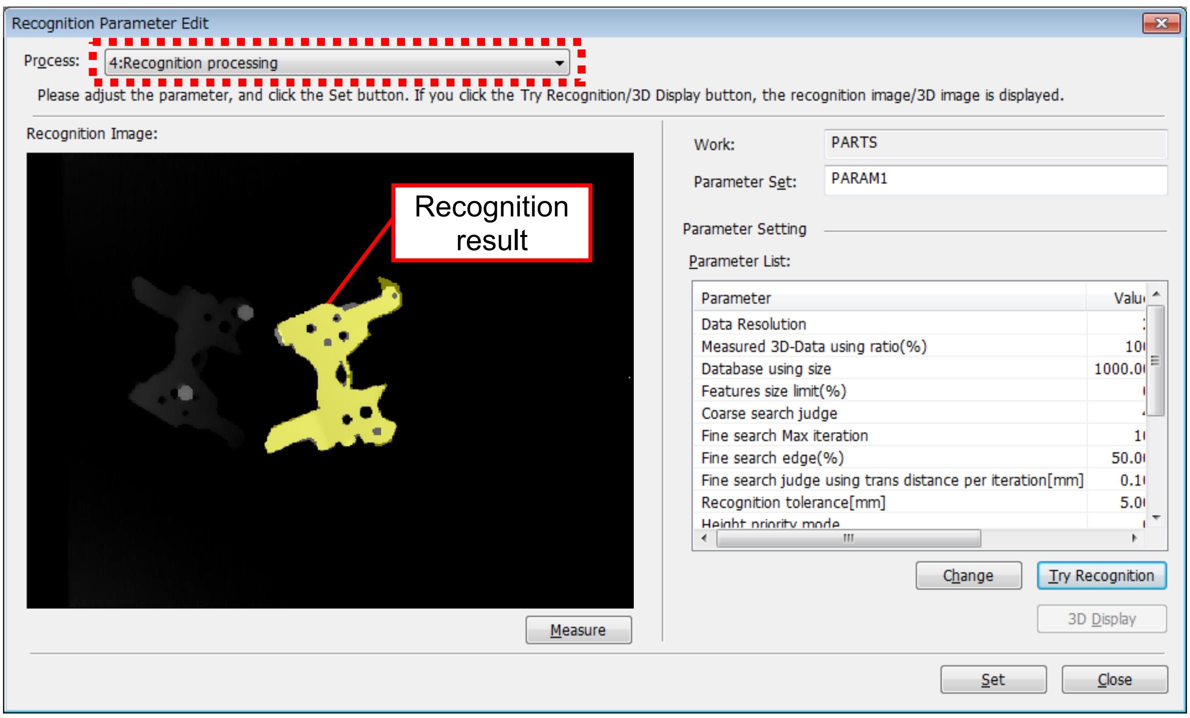


Fig. 7-121 Recognition processing

Table 7-30: Parameters for recognition processing

Parameter	Unit	Description	Range	Default setting
Data Resolution	-	Processing is performed after reducing the image to 1/n. The larger the value, processing is performed at high speed, however, accuracy drops.	1, 2	2
Measured 3D-Data using ratio	%	Percentage of measurement data used for features extraction. The larger the value, the more data is used and the more the recognition rate improves, however, the speed drops.	10 to 100	100
Database using size	-	Threshold of features reduction. The smaller the value, the more features are deleted and processing is performed at high speed, however, the recognition rate drops.	50 to 10000	1000
Features size limit	%	The lower limit of the extracted features size. The larger the value, the features of smaller size is not used, and processing is performed at high speed, however, the recognition rate drops.	0 to 100	0
Coase search judge	piece(s)	The smaller the value, the more posture candidates are calculated, however, the speed drops.	3 to 20	4
Fine search Max. iteration	times	If a small value is entered, emphasis is placed on the speed, and if a large value is entered, emphasis placed on accuracy.	1 to 50	10
Fine search edge	%	Parameter to determine how much the contour shape should be considered for detailed positioning of the surface fitting base.	0.0 to 100.0	50
Fine search judge using trans distance per iteration	mm	Processing is terminated when the estimated error for translation [mm] is equal to or lowers than the set value.	0.01 to 1.0	0.1
Recofnition tolerance	mm	Set the alignment torelance between the CAD model and 3D scan data.	0.1 to 10.0	5.0
Height priority mode	-	If this parameter is 1, the workpiece in the high position is preferentially recognized.	0: Score priority 1: High priority	0
Workpiece protruding ratio	%	The workpieces that the area that does not protrude from the recognition area is greater than or equal to the specified ratio become the recognition target.	50 to 100	50
Fitting area ratio	%	The workpieces that the area that not hidden by other workpieces is greater than or equal to the specified ratio become the recognition target.	50 to 100	90
Rotationally symmetrical workpiece: Shape	-	Specify the shape of rotationally symmetrical workpiece. (If the cuboid is specified, the rotationally symmetrical axes are x-axis and y-axis.)	0: Irrotational 1: Cylinder 2: Cuboid 3: Square prism 4: Reqular hexagonal prism	0
Rotationally symmetrical workpiece: Axis	-	Specify the rotationally symmetrical axis of the workpiece on the work coordinate system. (If the shape is the irrotational symmetrical or cuboid, the setting of this parameter is ignored.)	0: X-axis 1: Y-axis 2: Z-axis	0
The number of initial candidates	Pieces	Set the number of recognition candidates as initial candidates.	1 to 200	10

The number of recognition result	Pieces	Set the number of recognition candidates to be finally calculated. (This parameter does not affect the recognition time.)	1 to 10	1

Table 7-31: Items to be confirmed during recognition processing

No.	Items to be confirmed	Countermeasure
1	Check that the workpiece is not recognized several times.	When the same workpiece is recognized several times, change the value of the parameter "The number of recognition result" to 1.

Check the enlarged image screen for the recognition image or the 3D display screen displayed by clicking the [3D Display] button to confirm whether the position and posture for the measured workpiece and recognition result match.

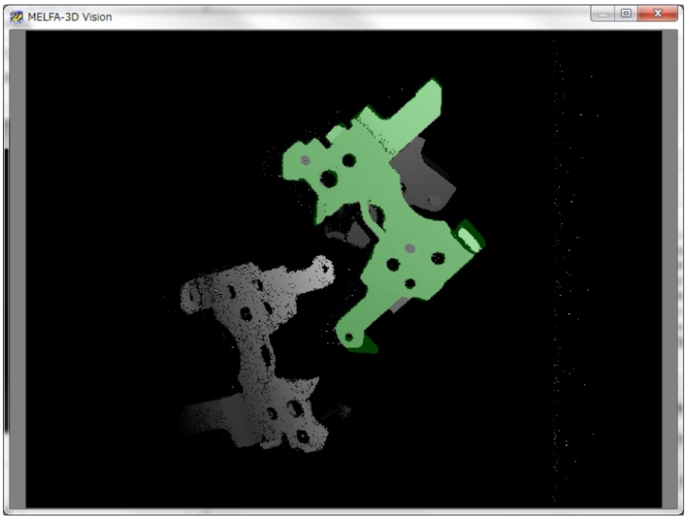


Fig. 7-122 Recognition processing successful example (2D display)

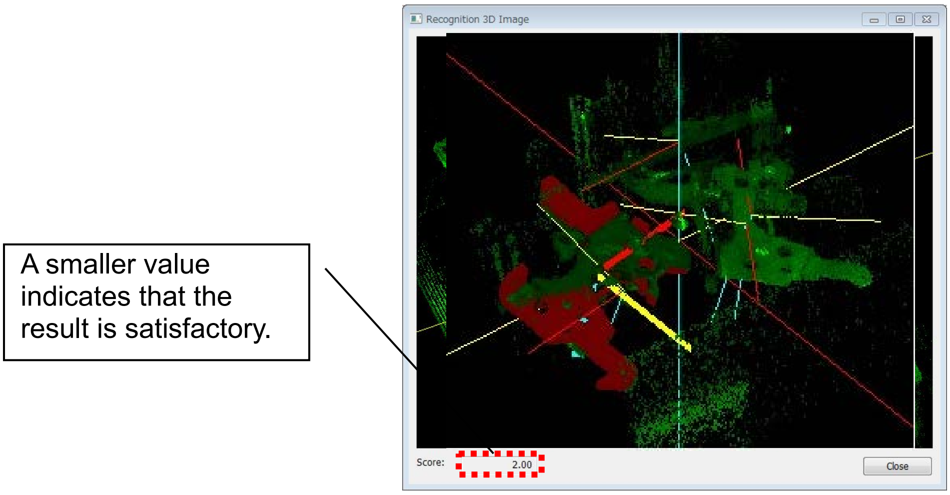


Fig. 7-123 Recognition processing successful example (3D display)

If there are no problems with the recognition time or recognition result, click the [Set] button and then close the Model-less recognition user settings screen. If wishing to change the parameter set name, change the parameter set field and then click the [Set] button.

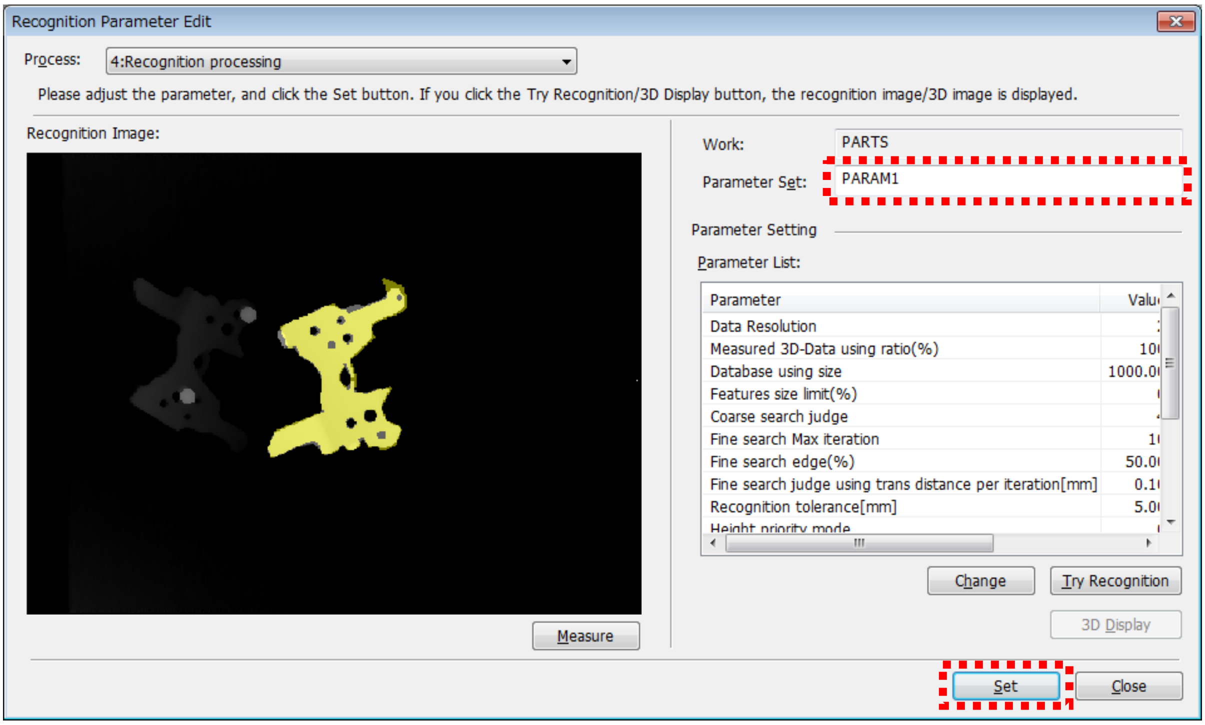


Fig. 7-124 Parameter set setting

Workpiece list registration

The following screen is used to create a workpiece list (Table 7-22). Click the [Register Work List] button, and then click the [Add] button at on the left of the Workpiece list registration screen that appears. A workpiece list name Note 1 entry screen appears. Enter an arbitrary workpiece list name and click the [OK] button.

Note 1: Up to 32 single-byte alphanumeric characters

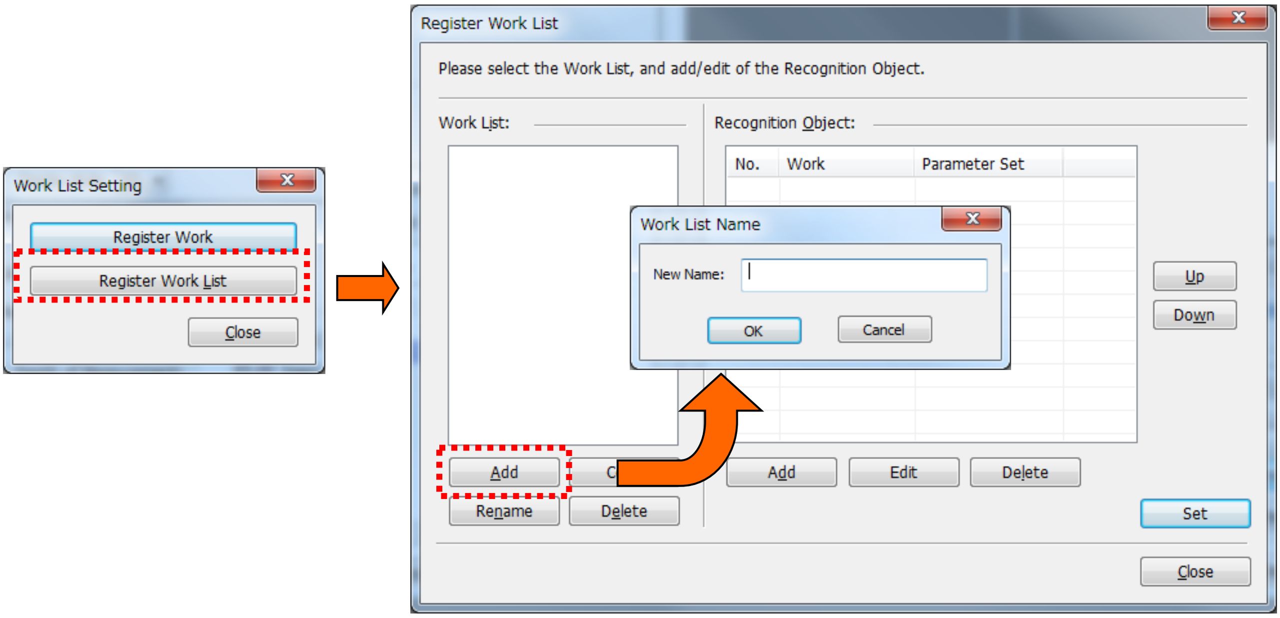


Fig. 7-125 Workpiece list registration

By then clicking the [Add] button on the right of the Workpiece list registration screen, a Recognition target addition screen appears. Select the workpiece and parameter set combination from the drop-down list, and then click the [OK] button. By repeating this process, a list of recognition targets to be registered in the workpiece is created.

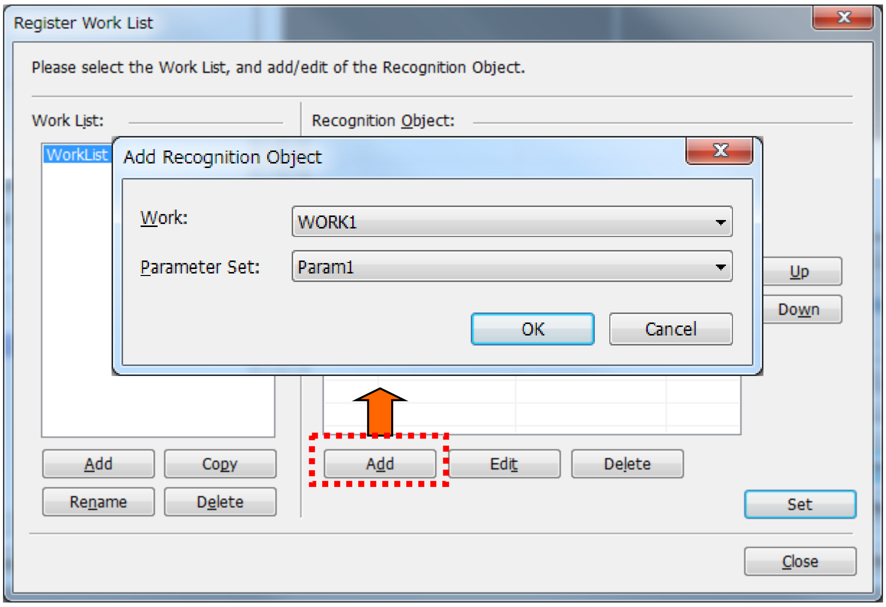


Fig. 7-126 Recognition target addition

By clicking the [Set] button, the created workpiece list is registered.

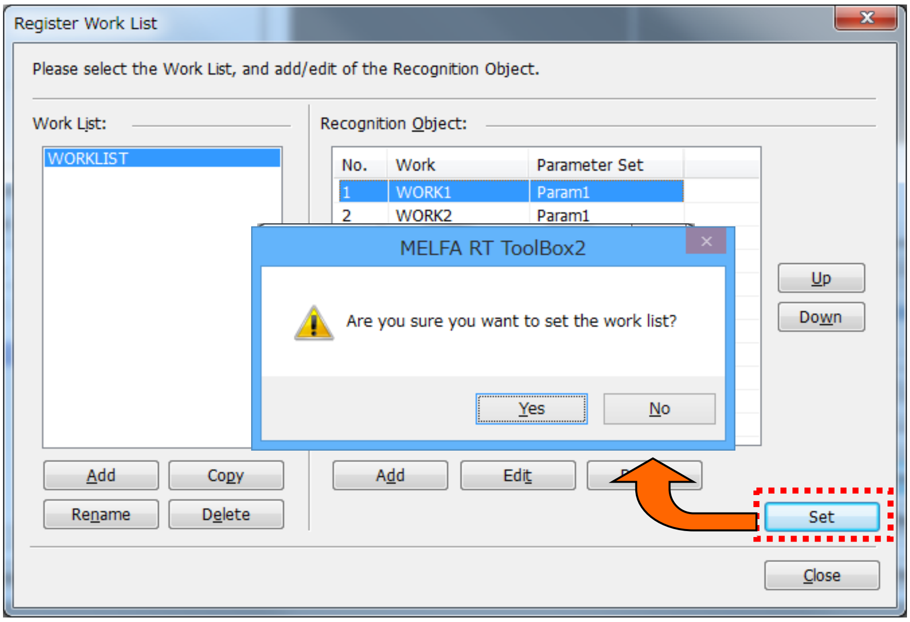


Fig. 7-127 Recognition target list

If changing the list order, select the row for the list No. to be changed from the list, and move the row by clicking the [Up] and [Down] buttons.

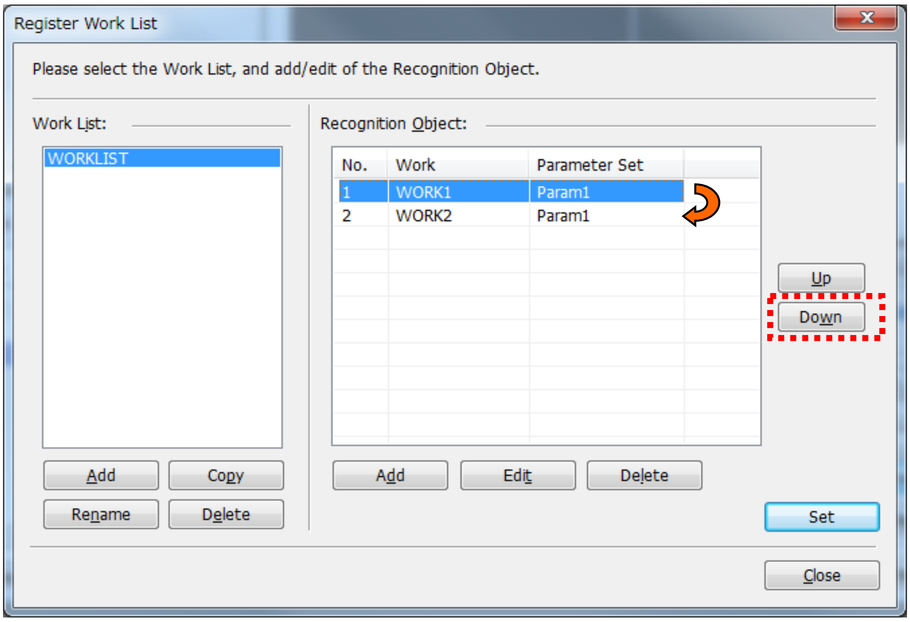
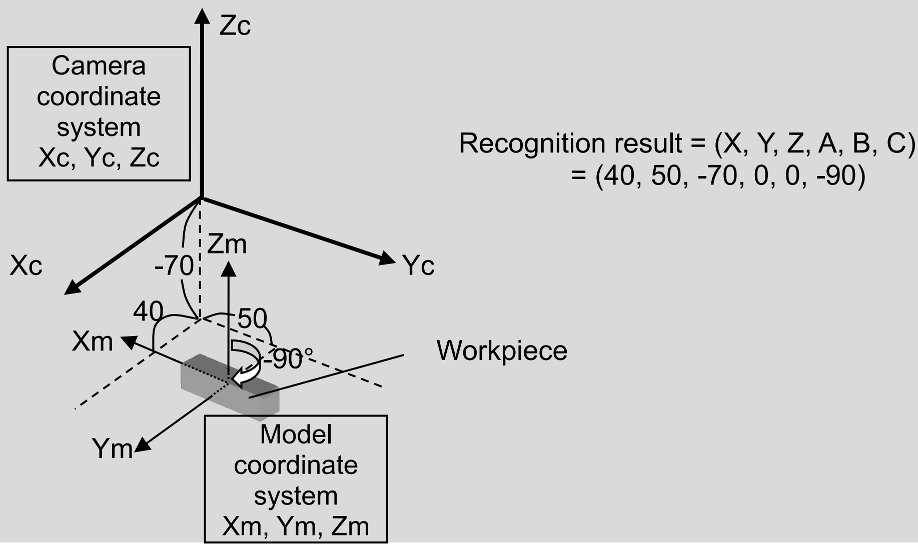


Fig. 7-128 List order change

<u>Checking the recognition results</u>
Change the position of the workpiece in the measurement range, or increase the number of workpieces. Click the [Measure] button to perform measurement. Then, select the workpiece list and the recognition target, and click the [Recognize] button. The recognition result with the best score from the recognized workpieces appears in the result field, and the image is displayed in green in the Recognition result screen. The recognition result is the model coordinate system position and posture viewed from the camera coordinate system (see Fig. 3-9).

By clicking the [Display List] button, other recognition results can also be viewed. Please note that the results are displayed in the list in order from the higher score.

◇◆◇Recognition result◇◆◇
The recognition results of X, Y, and Z components represent the model coordinate system origins, and the A, B, and C components represent the model coordinate system posture (rotation around Z-axis → around Y-axis → X-axis in this order) against the camera coordinate system.



◇◆◇Workpiece list and recognition target◇◆◇
The workpiece list specified here is saved to the job. The recognition target is specified with the V3Run command (see 8.1) when executed with the robot program.

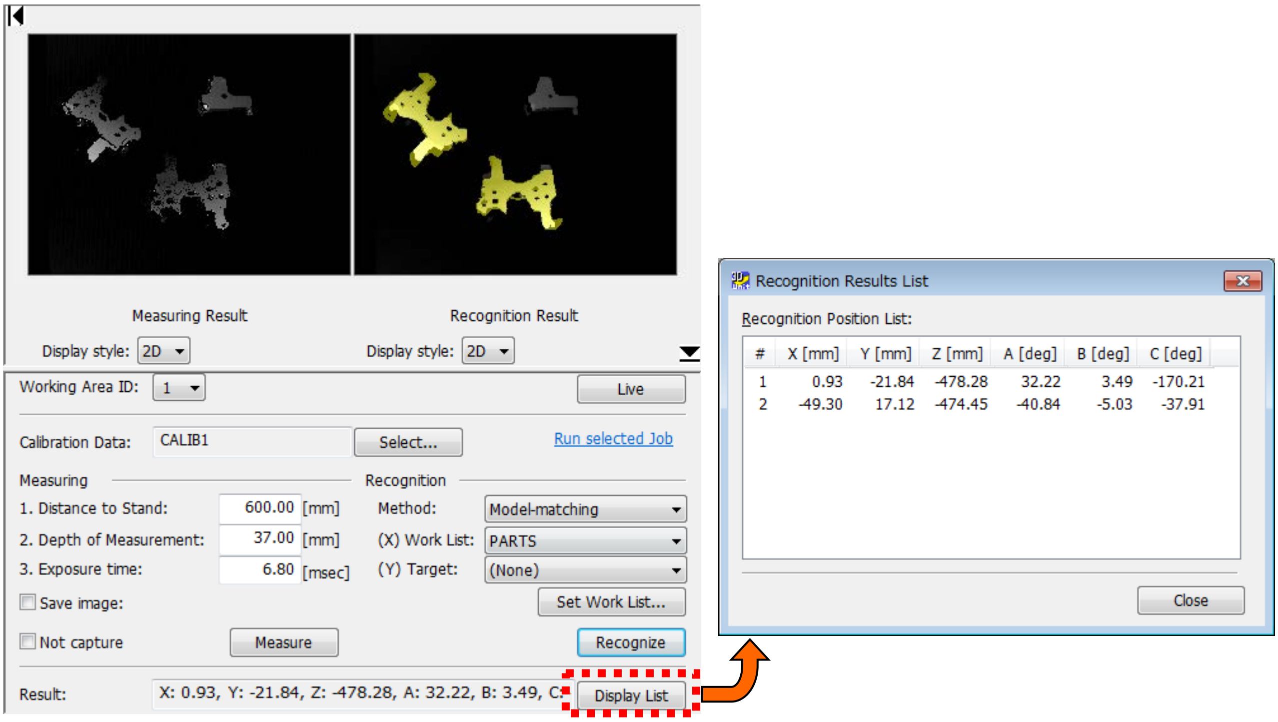


Fig. 7-129 Confirmation of recognition results

If there are no problems with the results, click the [Run selected Job] link to proceed to job execution.

7.9.1.4. Job Execution

By clicking the [Run] button in the Job execution screen, the created job can be executed. Measurement and recognition are only performed when the [Run] button is clicked if the respective check boxes adjacent to the measurement and recognition items are selected. If, for example, the recognition check box is cleared and only the measurement check box is selected, only measurement will be performed when the [Run] button is clicked. If, however, performing recognition only, it is necessary that measurement data is entered beforehand in the specified workspace ID.

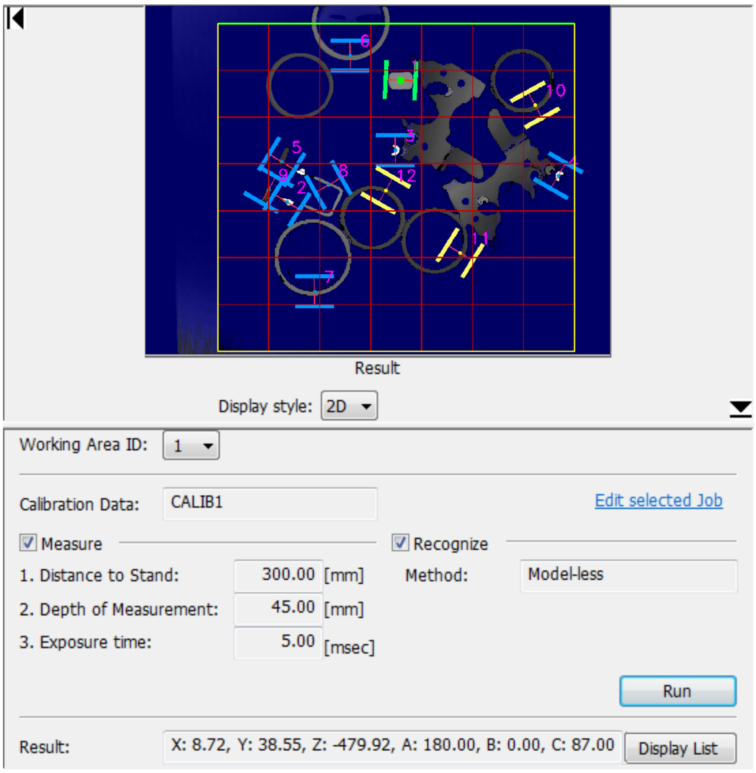


Fig. 7-130 Confirmation of recognition results

If trying to execute an existing job, by clicking [Start Up] - [3. Measuring/Recognition] - [3-3 Run Job] in the guidance menu, a Job selection screen appears. Select an existing job to display the Job execution screen.

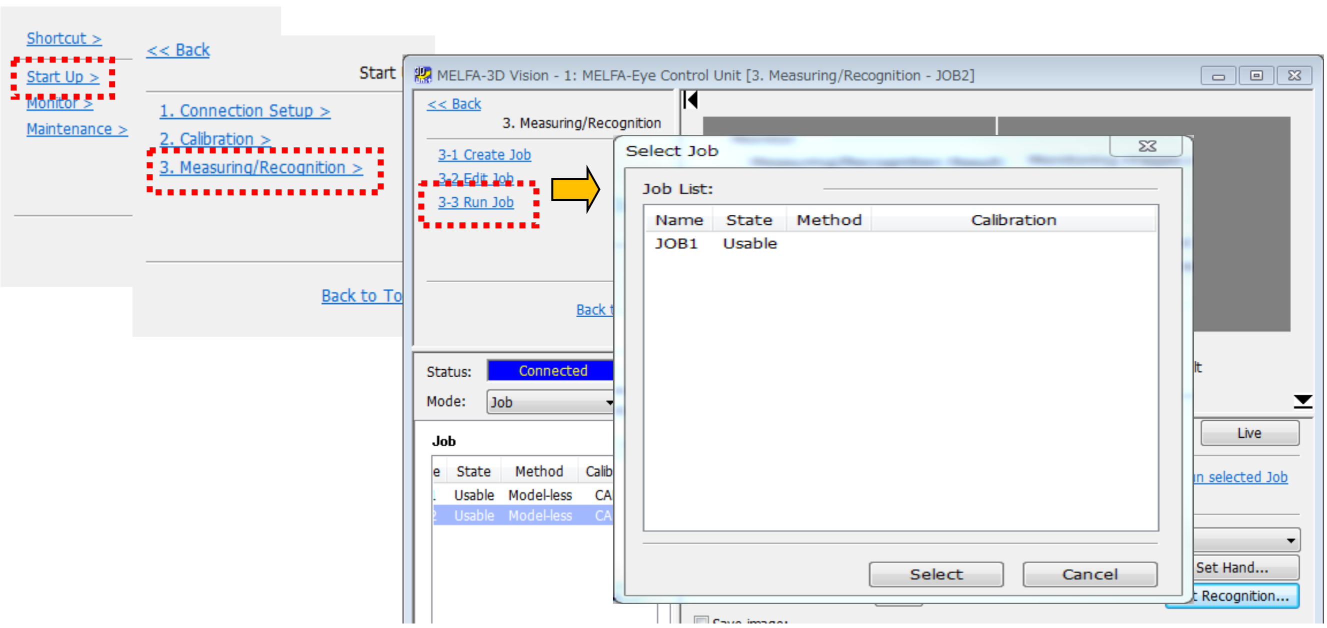
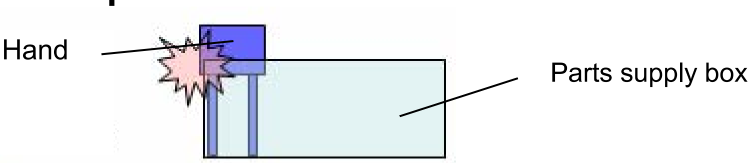


Fig. 7-131 Existing job execution

7.10. Picking

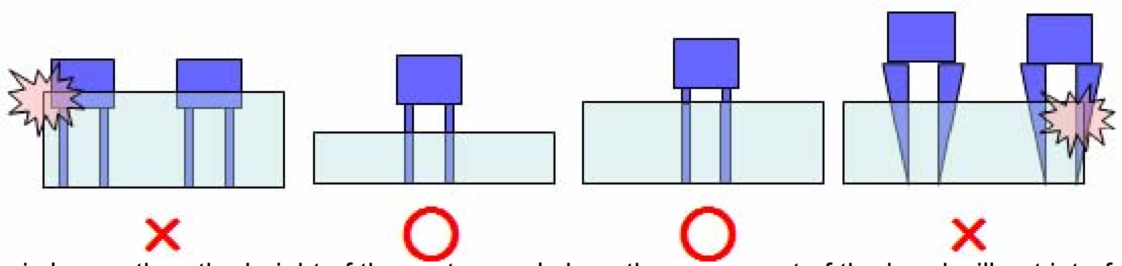
7.10.1. Hand claw shape



When using model-less recognition, it is necessary to pay attention to the following points when designing the hand claw in order to avoid interference with the parts supply box as shown in the above drawing.

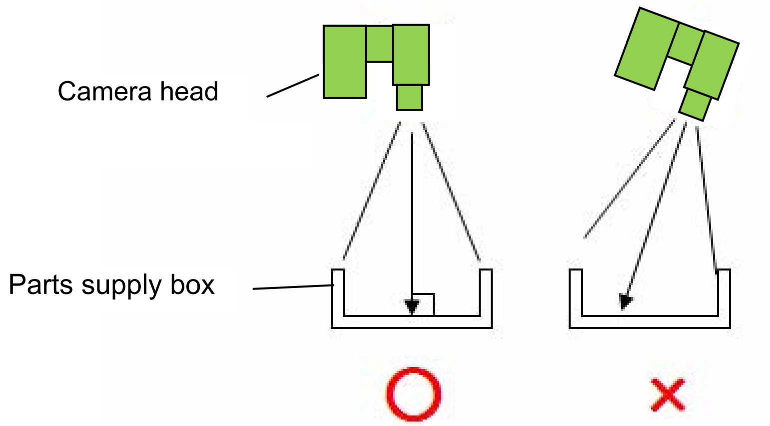
◆ The claw should be longer than the height of the parts supply box.

◆ The claw thickness should be uniform.

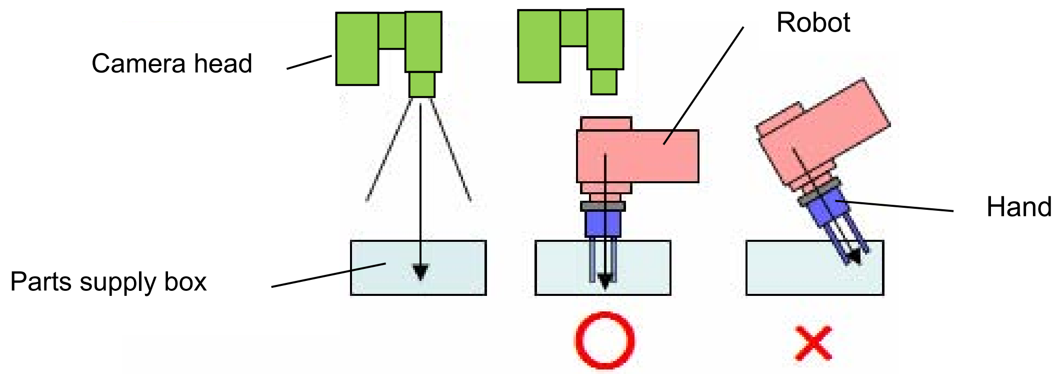


If the claw is longer than the height of the parts supply box, the upper part of the hand will not interfere with the box, however, if the claw thickness is not uniform as shown in the drawing in the upper right, the upper portion of the claw may interfere with the box when picking parts from the edge of the box. It is therefore necessary to make adjustments to avoid claw and parts supply box interference by making the claw thickness uniform, or by setting a recognition area sufficiently away from the wall of the parts supply box. Furthermore, interference can also be avoided by setting the recognition setting area smaller than the parts supply box.

7.10.2. Camera head installation method for model-less recognition



Make the camera head's line of sight direction (direction viewed by camera) perpendicular to the bottom of the parts supply box. As shown in the drawing above, if the bottom and the line of sight direction are not perpendicular to one another, workpiece recognition may fail, resulting in collision of the hand claw with the bottom, or malfunction of the residual amount detection.



Furthermore, if the hand entry direction to perform the take-out operation does not match the 3D camera's line of sight direction as shown in the drawing in the above right, the hand may collide with the parts supply box. Therefore, align the hand entry direction for picking with the line of sight direction.

7.10.3. Tool settings

For tool settings, perform setting of the X, Y, and Z components first, and then the A, B, and C component. The setting procedure is as follows. For details of general information on tools, refer to the separate "Instruction Manual/Detailed Explanations of Functions and Operations".

7.10.3.1. Setting the X, Y, and Z components

Set using the "Tool automatic calculation function". The "Tool automatic calculation function" is used to automatically calculate the tool length by teaching the same points in three to eight points against the position to be set as a control point, allowing the tool parameter (MEXTL) value to be set.

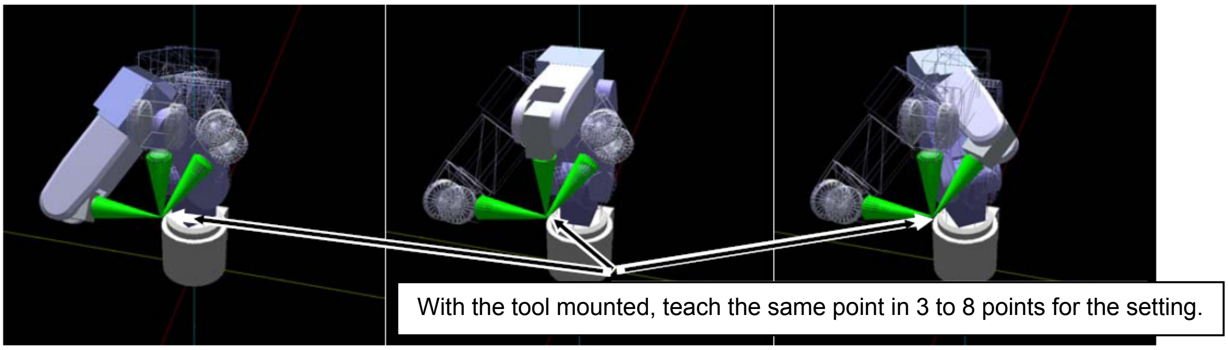


Fig. 7-132 Tool automatic calculation overview

The tool automatic calculation function is used with RT ToolBox2 and the robot controller connected. Select [Online] - [Maintenance] for the applicable project from the project tree, and then double-click [Tool automatic calculation].

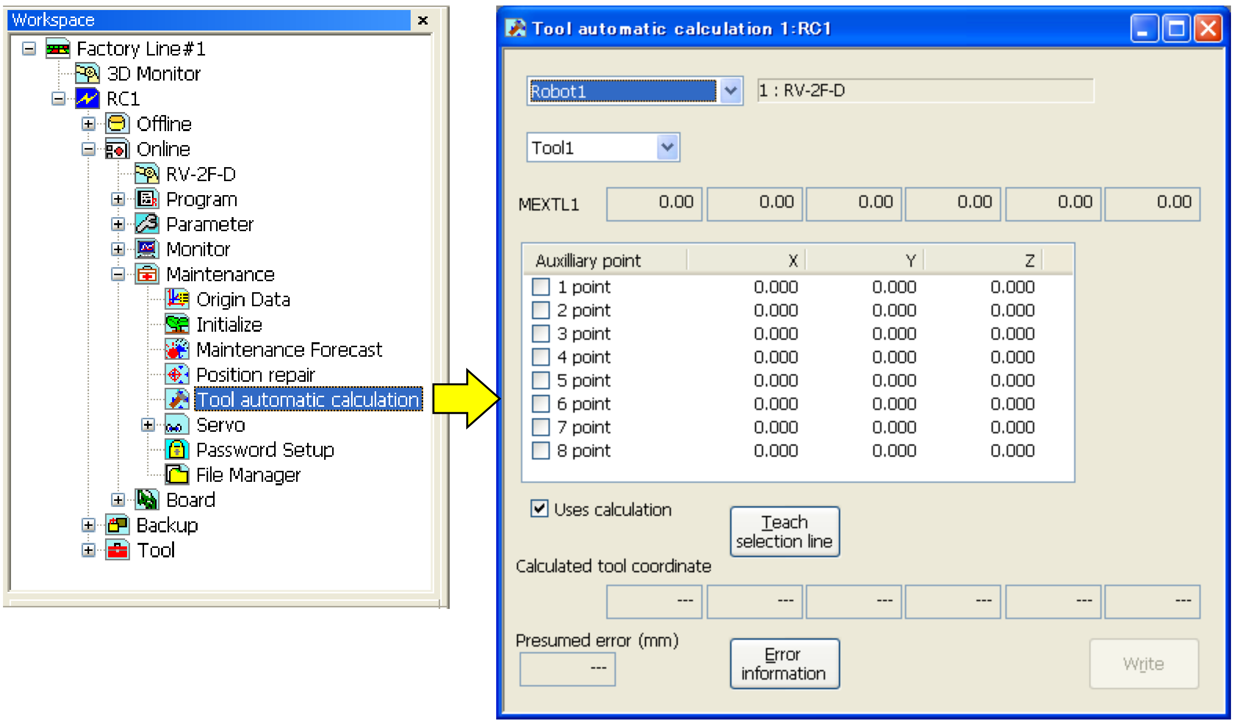


Fig. 7-133 Starting tool automatic calculation

Perform tool automatic calculation using the following procedure.
(1) Select the target robot <a> and the tool number <b>.
(2) Move the robot with the tool mounted. After selecting the line of "Auxiliary point list" <c>, click the [Teach selection line] button <d>. Teach the same position in three points or more from different postures against the position to be set as a control point.
(3) By clicking the [Error information] button <f>, it is possible to check the presumed error of the calculated tool length. If the presumed error does not lie within the permissible range, return to (2) and increase the number of auxiliary points used for calculation.
(4) When a value is set to the "Calculated tool coordinate", the [Write] button <e> becomes active. By clicking the [Write] button <e>, the tool parameter (MEXTL) is written to the robot controller.

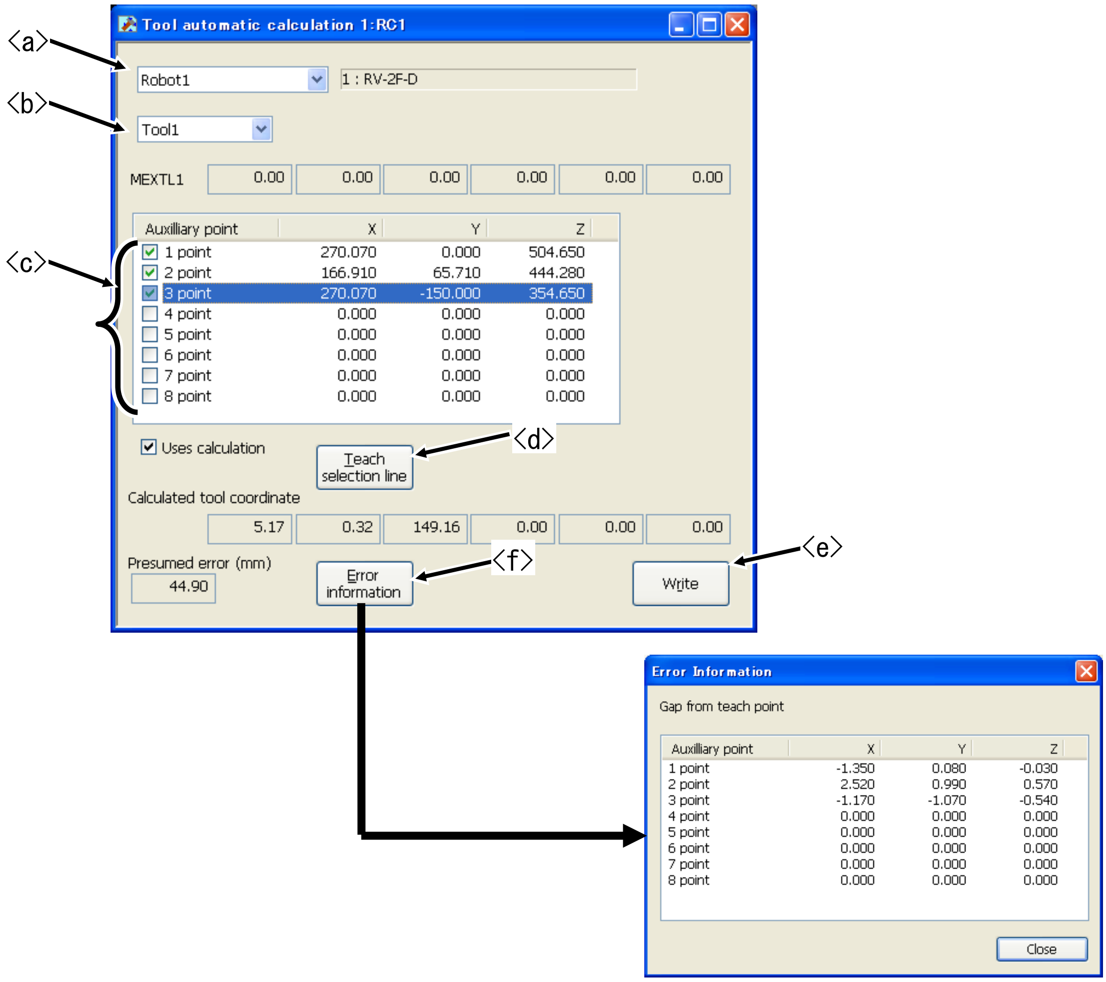


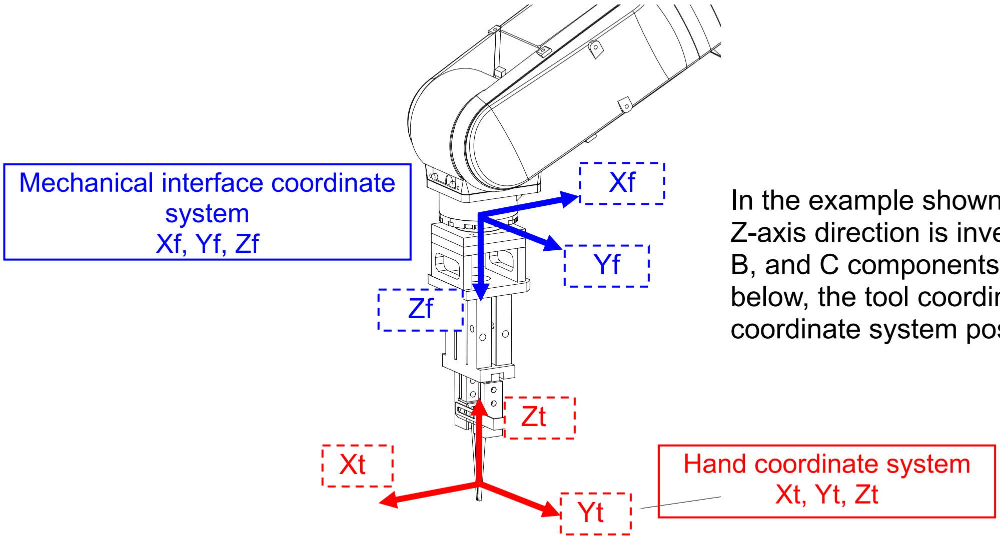
Fig. 7-134 Performing tool automatic calculation

◇◆◇Teaching points◇◆◇

- Teach the position by greatly changing the posture of the robot. If similar postures are used (only the A axis differs, for example), the tool coordinate may not be calculated.
- For model-less recognition, teach the same point against the origin of the hand coordinate system.

7.10.3.2. Setting the A, B, and C components

Set the tool A, B, and C components so that the tool coordinate system posture matches the hand coordinate system posture.



In the example shown on the left where the Z-axis direction is inverted, by setting the A, B, and C components of the tool as shown below, the tool coordinate system and hand coordinate system posture match.

Fig. 7-135 Tool A, B, and C component setting example

◇◆◇When model-less recognition is used◇◆◇

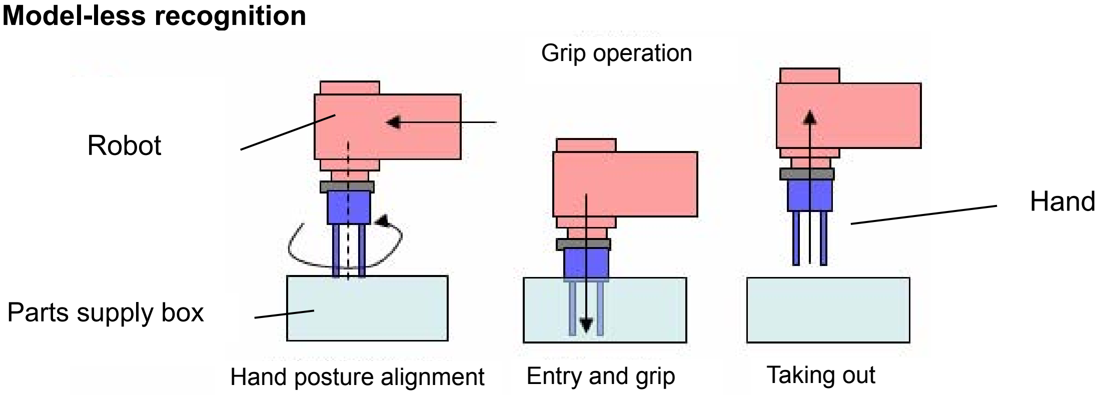
- Based on the value set for the recognition parameter posture output mode, the Z-axis direction of the hand coordinates system matches the Z-axis direction of the mechanical interface coordinates system. (Refer to Table 7-20 Posture output mode.)

⚠ CAUTION

It should be noted that by setting the A, B, and C components, the Z-axis direction is reversed from the tool coordinate default value. Therefore, the approach distance and pullout distance (Mvs only) direction specified with Mov and Mvs will also change.

7.10.4. Creating robot programs

7.10.4.1. Model-less recognition



To perform picking, control the robot in three separate phases as shown below.

(1) Align the hand posture (hand posture alignment) by the time it moves over the parts supply box.
(2) Move the hand perpendicularly to the floor (entry and gripping).
(3) After picking, move the hand in the direction opposite to the entry direction (taking-out operation).

If the hand approaches the parts supply box during position alignment, the hand may interfere with surrounding workpieces in the course of entry and displace positions of the workpieces, resulting in unsuccessful picking. Therefore, by moving the hand to enter the box from the line of sight direction, minimum interference with workpieces is assured to achieve stable picking.

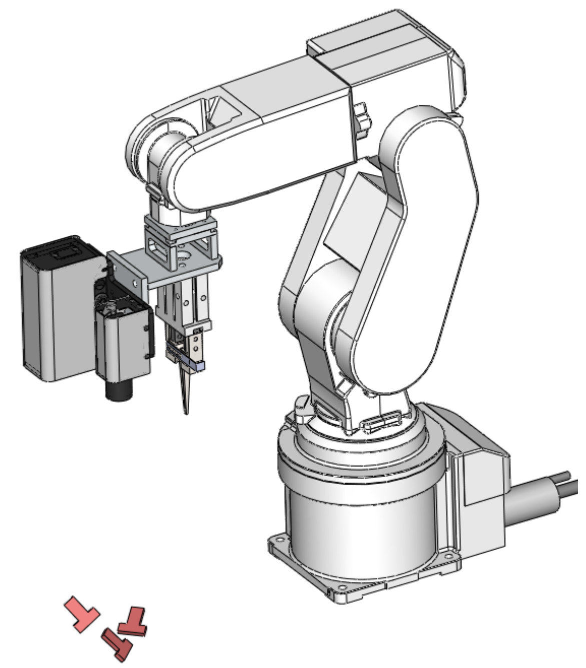
A sample program is shown below.

Bulk picking using hand eye

■ Operation details

Gripping and delivery of bulk loaded workpieces

- The hand moves to the measurement position, JOB 1 is executed for measurement and recognition.
- The hand moves to the hand posture alignment position.
- The hand moves to the workpiece grip position and grips the workpiece.
- The workpiece is taken out.
- The workpiece is delivered.



■ Program example <Sample Program JMLH.prg>

```
'[Connection to MELFA-3D Vision]
If M_Open(1) <> 2 Then                  'If vision sensor No. 1 is not capable of measurement
  V3Open "COM2:" As #1                  'Connect to vision sensor connected to COM2:, and set number to 1.
EndIf
Wait M_Open(1) = 2                      'Connect to vision sensor No. 1 and wait until measurement is possible.
'[Measurement and recognition]
*CapAndRecg
Mov PCap                                'Move to measurement position (position shown in drawing above).
Dly 1                                   'Wait for robot tip vibrations to subside.
V3Run #1,"JOB1", 1, 1, 1, 1, 1          'Execute "JOB1" Note 1.
*Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1   'Wait until result received from MELFA-3D Vision.
If M_V3Rslt(1) <> 0 Then Error 9100     'Output error 9100 if unsuccessful.
MNum = M_V3Num(1)                       'Store recognition count in MNum.
If MNum = 0 Then Goto *FIN              'Recognition count is 0 and therefore finished.
PRcg = P_V3Pos(1, 1)                    'Recognition result acquisition Note 2
'[Hand posture alignment position and workpiece grip position calculation]
PRot = P_Zero
If Deg(PRcg.C)>+90 Then PHnd.C = -180DEG   'Corrected value to prevent camera head collision Note 2
If Deg(PRcg.C)<-90 Then PHnd.C = +180DEG   'Corrected value to prevent camera head collision Note 2
'------------ Hand posture alignment position calculation ----------
PAp = PRcg
PAp.Z = 150                             'Substitute the height of space above the part supply box.
PAp = PAp * PHnd                        'Calculate the alignment position of hand postures.
If Deg(PRcg.A)>+45 Then PAp.A = +45DEG  'Correction to prevent peripheral interference Note 3
```

```
If Deg(PRcg.A)<-45 Then PAp.A = -45DEG        'Correction to prevent peripheral interference Note 3
If Deg(PRcg.B)>+45 Then PAp.B = +45DEG        'Correction to prevent peripheral interference Note 3
If Deg(PRcg.B)<-45 Then PAp.B = -45DEG        'Correction to prevent peripheral interference Note 3
'------------ Entry/grip position calculation ----------
PGet = PAp
PGet.Z = PRcg.Z - 20                           'PRcg.Z is the position on top of the workpiece, and
therefore the amount of claw penetration is subtracted Note 4.
'[Move to hand posture alignment position and workpiece grip position, and grip workpiece]
Mvs PAp                                        '(1) Hand posture alignment
Mvs PGet                                       '(2) Entry, grip
Dly 0.5
HClose 1
Dly 0.5
Mvs PAp                                        '(3) Taking out
'[Move to workpiece delivery position, and deliver workpiece]
Mov PRel
Dly 0.5
HOpen 1
Dly 0.5
GoTo *CapAndRecg
'
*FIN
V3Close #1                                     'Disconnect from vision sensor connected to COM2.
End
```

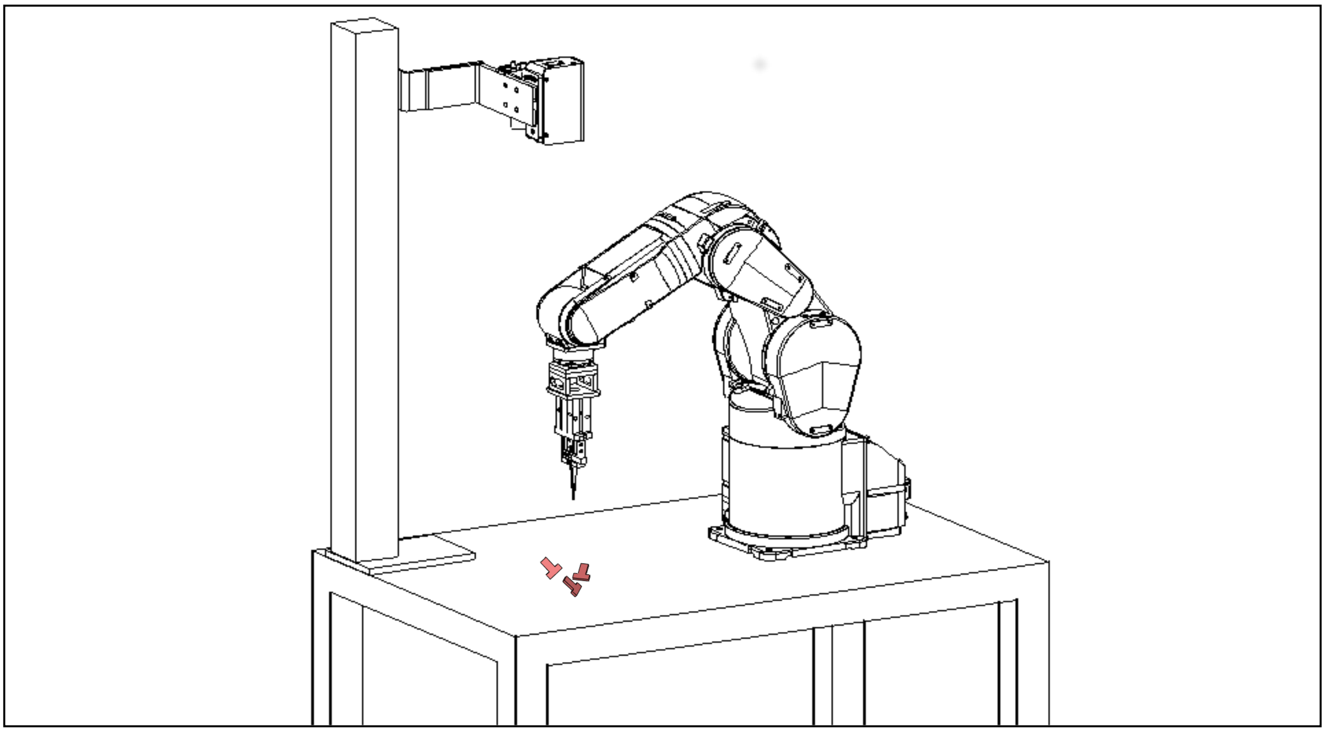
Note 1: The camera installation type set in the calibration data must be "Hand".
Note 2: As for the recognition result values obtained with P_V3Pos( ), X, Y, and Z are the positions in the base coordinate system, and C is the rotation angle around the Z-axis in the camera coordinate system.
Note 3: When the posture output mode 2 or 4 is selected, take into account interference with the periphery.
Note 4: Set the thrust amount to roughly three fourths of the workpiece height.

Bulk picking using fixed camera

■ Operation details

Gripping and delivery of bulk loaded workpieces

- The robot moves to the escape position.
- JOB1 is executed for measurement and recognition.
- The hand moves to the hand posture alignment position.
- The hand moves to the workpiece grip position and grips.
- The workpiece is taken out.
- The workpiece is delivered.



■ Program example <Sample Program JMLF.prg>

```
'[Connection to MELFA-3D Vision]
If M_Open(1) <> 2 Then                          'If vision sensor No. 1 is not capable of measurement
   V3Open "COM2:" As #1                     'Connect to vision sensor connected to COM2: and set number to 1.
EndIf
Wait M_Open(1) = 2                      'Connect to vision sensor No. 1 and wait until measurement is possible.
While 1
   '[Measurement, recognition]
   Mov PEva                                     'Move to escape position.
   V3Run #1,"JOB2", 1, 1, 1, 1, 1               'Execute "JOB2" Note 1.
   *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1  'Wait until result received from MELFA-3D Vision.
   If M_V3Rslt(1) <> 0 Then Error 9100         'Output error 9100 if unsuccessful.
   MNum = M_V3Num(1)                            'Store recognition count in MNum.
   If MNum = 0 Then Goto *FIN                   'Recognition count is 0 and therefore finished.
   PRcg = P_V3Pos(1, 1)                         'Recognition result acquisition Note 2
   '[Hand posture alignment position and workpiece grip position calculation]
   '------------ Hand posture alignment position calculation ----------
   PAp = PRcg
   PAp.Z = 150                                  'Substitute the height of space above the part supply box.
   If Deg(PRcg.A)>+45 Then PAp.A = +45DEG       'Correction to prevent peripheral interference Note 2
   If Deg(PRcg.A)<-45 Then PAp.A = -45DEG       'Correction to prevent peripheral interference Note 2
   If Deg(PRcg.B)>+45 Then PAp.B = +45DEG       'Correction to prevent peripheral interference Note 2
   If Deg(PRcg.B)<-45 Then PAp.B = -45DEG       'Correction to prevent peripheral interference Note 2
   '------------ Entry/grip position calculation ----------
   PGet = PAp
   PGet.Z = PRcg.Z - 20                         'PRcg.Z is the position on top of the workpiece, and
therefore the amount of claw penetration is subtracted Note 3.
   '[Move to hand posture alignment position and workpiece grip position, and grip workpiece]
   Mvs PAp                                      '(1) Hand posture alignment
   Mvs PGet                                     '(2) Entry, grip
   Dly 0.5
   HClose 1
   Dly 0.5
```

```
   Mvs PAp                                    '(3) Taking out
   '[Move to workpiece delivery position, and deliver the workpiece]
   Mov PRel
   Dly 0.5
   HOpen 1
   Dly 0.5
   Mvs PAp
WEnd
'
*FIN
V3Close #1                                 'Disconnect from vision sensor connected to COM2.
End
```

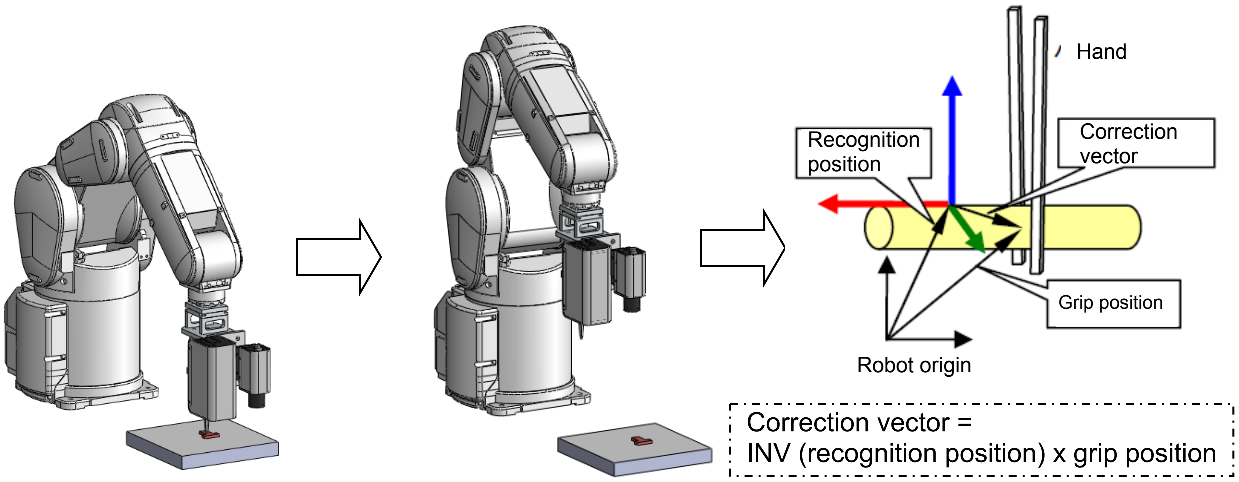
Note 1: The camera installation type set in the calibration data must be "Fixed".
Note 2: When the posture output mode 2 or 4 is selected, take into account interference with the periphery.
Note 3: Set the thrust amount to roughly three fourths of the workpiece height.

7.10.4.2. Model matching recognition

<u>Grip posture teaching</u>

The workpiece recognition position and the grip position for model matching recognition are different. Therefore, it is necessary to calculate a correction vector to correct the deviation beforehand. The correction vector calculation method is described below.

(1) Obtain the grip position by moving the hand claw or the suction pad to the intended workpiece grip position.
(2) Obtain the recognition position by moving the hand to the measurement position and performing workpiece measurement and recognition.
(3) Calculate the correction vector by multiplying INV (recognition position) by the grip position.



(1) Move to the grip position and perform teaching.

(2) Move to the measurement position and perform recognition.

(3) Calculate the correction vector.

Fig. 7-136 Correction vector calculation

It should be noted that the workpiece has various postures such as facing sideways or reversed. Therefore, there is a position in which the workpiece can be gripped easily for each posture, even if the workpiece itself is the same. Consequently, it is necessary to find the correction vector from the grip position corresponding to the recognition position at each posture. Therefore, repeat the above procedure (a) to (c) to calculate the correction vector for each of multiple stable postures of the workpiece.

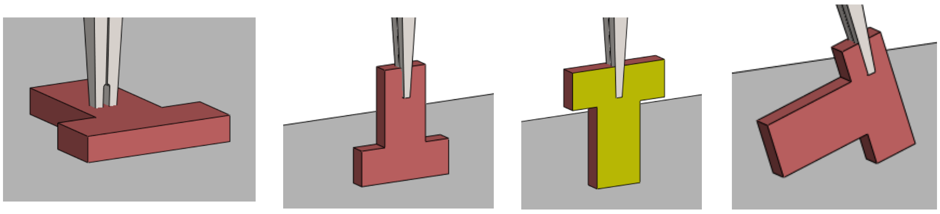


Fig. 7-137 Correction vector calculation

Please note that correction vectors can be calculated using sample program JMMP.prg contained in the provided CD-ROM.

(a) Teach the measurement position (PCap) and then execute sample program JMMP.prg.
  * Connect to MELFA-3D Vision and then stop at the temporary stoppage line.
(b) Place the workpiece in the measurable area, jog the robot to move the hand claw or the suction pad to the grip position, and then teach the current position to PG_CATCH(n).

◇◆◇Teaching precautions◇◆◇
Perform PG_CATCH(n) teaching as follows so that the program execution line does not return to the beginning.
[R3xTB] Perform teaching in the position editing screen and then save.
[RT ToolBox2] Perform teaching, clear the command line check box at the write items for saving of the program, and then save.
[R5xTB] Perform teaching in the position editing screen, and then save without changing the program.

(c) Execute sample program JMMP.prg. By doing so, the robot moves to the measurement position, and after performing workpiece measurement and recognition, the correction vector (PMAT(n)) is calculated by multiplying INV (recognition position) by the grip position.

Change the workpiece posture and repeat (b) and (c) for the number of possible postures.

■Program example <Sample Program JMMP.prg>

```
'[Arrangement declaration]
Dim PMAT(10)              'Correction vector * Change number of elements based on number of grip positions.
Dim PG_CATCH(10)          'Grip position * Change number of elements based on number of grip positions.
'[Connection to MELFA-3D Vision]
If M_Open(1) <> 2 Then    'If vision sensor No. 1 is not capable of measurement
  V3Open "COM2:" As #1    'Connect to vision sensor connected to COM2: and set number to 1.
EndIf
Wait M_Open(1) = 2        'Connect to vision sensor No. 1 and wait until measurement is possible.
'[Correction vector calculation]
For MNO = 1 To 10         'Loop for the number of grip positions to be taught.
  Hlt                     'Temporary stop
  Mov PCap                'Move to measurement position.
  Dly 1                   'Wait for robot tip vibrations to subside.
  V3Run #1,"JOB1", 1, 1, 1, 1, 1                   'Execute "JOB1"
  *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1       'Wait until result received from MELFA-3D Vision.
  If M_V3Rslt(1) <> 0 Then Error 9100              'Output error 9100 if unsuccessful.
  MNum = M_V3Num(1)                                'Store recognition count in MNum.
  If MNum = 0 Then Goto *FIN                       'Recognition count is 0 and therefore finished.
  PVSDATA = P_V3Pos(1, 1)
  PMAT(MNO) = Inv(PVSDATA) * PG_CATCH(MNO)                   'Correction vector calculation
Next
'
*FIN
V3Close #1                                         'Disconnect from vision sensor connected to COM2.
End
```

Picking

Perform picking by the following procedure using the correction vector calculated beforehand.

(1) Move to the measurement position, perform workpiece measurement and recognition, and obtain the recognition position.

(2) Use the correction vector (N) to calculate all grip position candidates (N) based on the recognition position.
Grip position candidates (N) = grip position x correction vector (N)

(3) Compare the teaching grip position (N) and the grip position candidate (N) according to the following conditions, and then select the execution grip position.
<Selection conditions>
- Within operating range
- Smallest difference in angle between teaching grip position postures
- Within permissible gripping angle

(4) Move to the execution grip position and grip the workpiece.

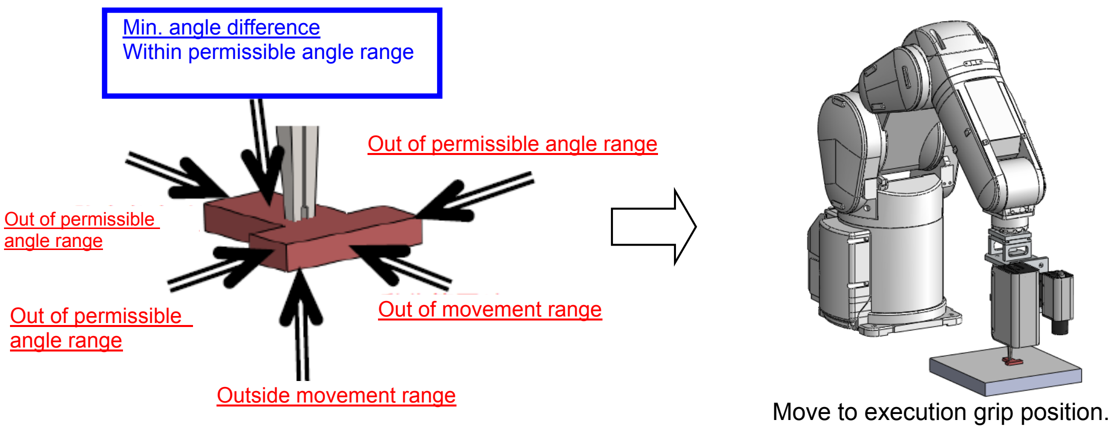


Fig. 7-138 Execution grip position

A sample program is shown below.

Random picking

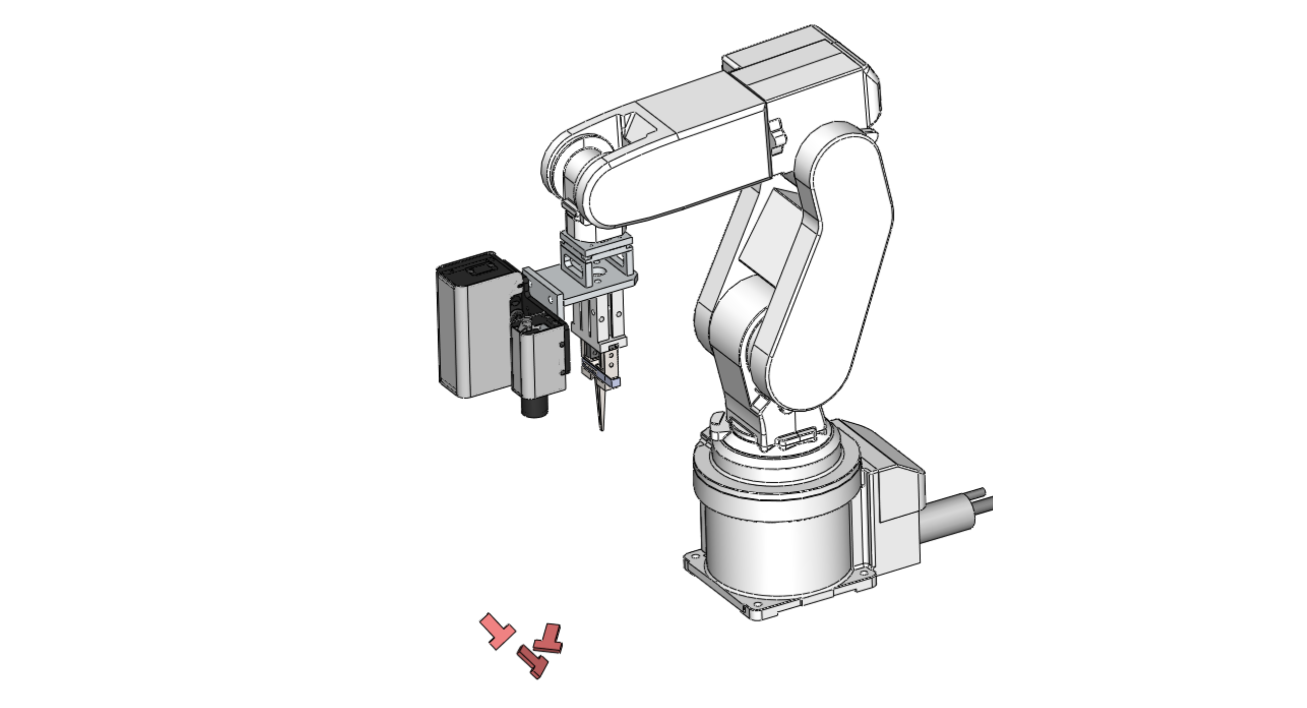
■ Operation details

Gripping and delivery of bulk loaded workpieces

- The hand moves to the measurement position, and JOB 1 is executed for measurement and recognition.
- The execution workpiece position is selected from the grip position candidates obtained using the workpiece recognition position and correction vector.
- The hand moves to the execution grip position and grips the workpiece.
- The workpiece is taken out.
- The workpiece is delivered.

CAUTION

Since checking of occurrence of interference with surrounding objects for gripping of workpiece is not performed, do not use a parts supply box and load workpieces in bulk on a flat surface.



■Sample program <Sample Program JMMH.prg>

```
'[Arrangement declaration]
Dim PMAT(10)                ‘Correction vector: Enter correction vector calculated beforehand.
Dim PG_GRASP(10)            ‘Grip position candidate
Dim PG_CATCH(10)            ‘Teaching grip position
Dim MFLAG(10)               ‘Within operating range flag
'[Variable initialization]
MDEG = 20                   'Angle threshold between teaching position and recognition grip position
'[Connection to MELFA-3D Vision]
If M_Open(1) <> 2 Then      'If vision sensor No. 1 is not capable of measurement
  V3Open "COM2:" As #1      'Connect to vision sensor connected to COM2: and set number to 1.
EndIf
Wait M_Open(1) = 2          'Connect to vision sensor No. 1 and wait until measurement is possible.
While 1
  '[Measurement, recognition]
  Mov PCap                  'Move to measurement position.
  Dly 1                     'Wait for robot tip vibrations to subside.
```

```
    V3Run #1,"JOB1", 1, 1, 1, 1, 1          'Execute "JOB1" Note 1.
    *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1     'Wait until result received from MELFA-3D Vision.
    If M_V3Rslt(1) <> 0 Then Error 9100            'Output error 9100 if unsuccessful.
    MNum = M_V3Num(1)                              'Store recognition count in MNum.
    If MNum = 0 Then Goto *FIN                     'Recognition count is 0 and therefore finished.
    PVSDATA = P_V3Pos(1, 1)                        'Acquire recognition result.
    '[Operating range check]
    MY02CHK = 0
    FOR MI = 1 TO 10
      PG_GRASP(MI) = PVSDATA * PMAT(MI)
      MFLAG(MI) = PosCq(PG_GRASP(MI))
      MY02CHK = MY02CHK + MFLAG(MI)
    NEXT MI
    IF MY02CHK = 0 THEN Error 9110         'Output error 9110 if all grip positions lie outside the operating range.
     '[Selection of grip position candidate for which difference in posture angle from teaching grip position is smallest]
    MIPMIN = -2
    FOR MI = 1 TO 10
      IF MFLAG(MI) = 1 THEN
         PCATCH  = PG_CATCH(MI)
         PGRASP  = PG_GRASP(MI)
        MIP = Dot(PCATCH, PGRASP)
                        'Convert specified position coordinates to unit vector and obtain inner product.
        IF MIP > MIPMIN THEN
          PG_PICK = PG_GRASP(MI)
          MIPMIN = MIP
        Endif
      Endif
    NEXT MI
         '[Check of difference in angle from teaching grip position]
    MTHRE = Cos(Rad(MDEG))
    IF MIPMIN < MTHRE THEN Error 9120
         'Output error 9120 if angular difference between teaching grip position and grip position exceeds threshold.
    '[Move to workpiece grip position ad grip workpiece]
    Mov PG_PICK, -30
    Mvs PG_PICK
    Dly 0.5
    Hclose 1
    Dly 0.5
    Mvs PG_PICK, -30
    '[Move to workpiece delivery position, and deliver workpiece]
    Mov PRel, -30
    Mvs PRel
    Dly 0.5
    HOpen 1
    Dly 0.5
    Mvs PRel, -30
WEnd
'[Termination processing]
*FIN
V3Close #1                          'Disconnect from vision sensor connected to COM2.
End
```

Note 1: See 8.1

7.10.5. Operation check

7.10.5.1. Monitoring

Jobs being executed are monitored. By clicking [Monitor] - [Measuring/Recognition] in the guidance menu at the MELFA-3D Vision setting screen, a Measurement/recognition results screen appears.

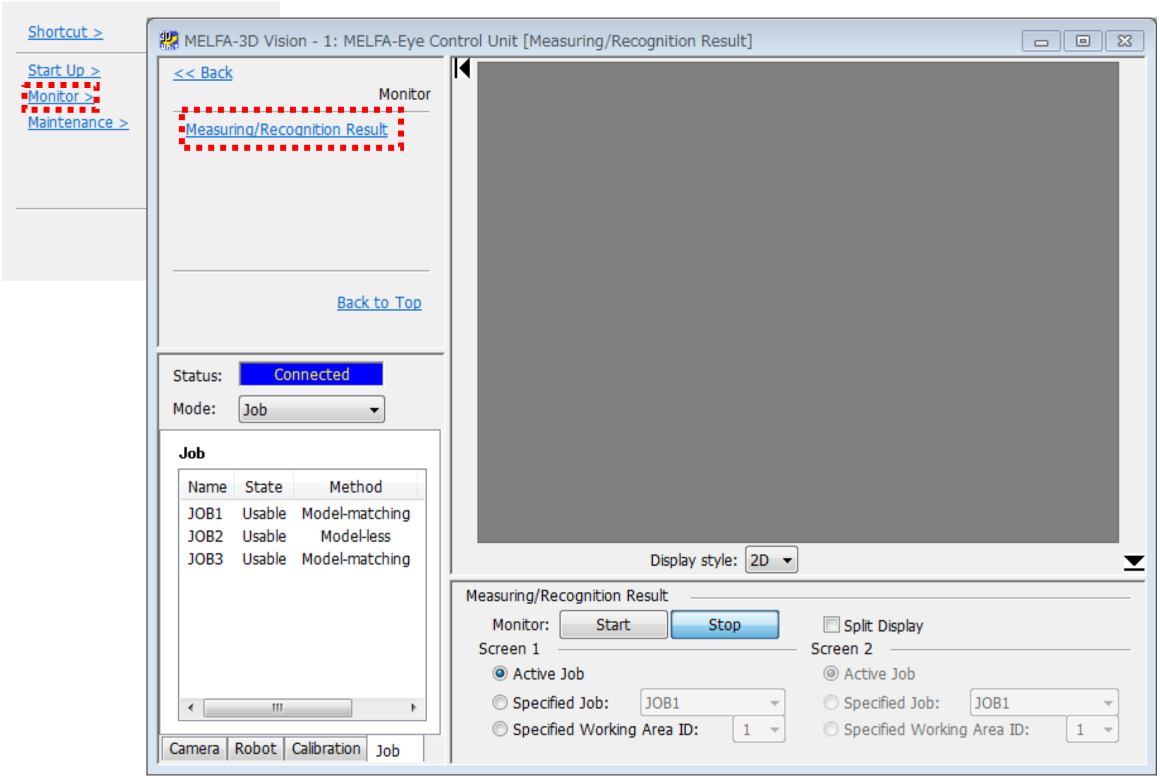


Fig. 7-139 Measurement and recognition results

The monitoring target can be selected from the following three.

Table 7-32 Monitoring types

Item	Description
Active Job	Monitors measurement and recognition results for the job currently being executed.
Specified Job	Monitors measurement and recognition results only for specified jobs.
Specified Working Area ID	Monitors measurement and recognition results stored in specified workspaces.

By selecting one of the above and clicking the [Start] button, monitoring is started.
Please note that two targets can be monitored simultaneously by selecting the "Two-division display" check box.

7.11. Maintenance

7.11.1. Backup and restoration

Information stored inside the control unit can be backed up to the computer.
Furthermore, backup information saved to the computer can be restored to the control unit.

Fig. 7-33: Backup and restoration

Item	Description
Backup (Control unit →computer)	Saves a backup of data in the control unit to the computer.
Restoration (Computer →control unit)	Transfers backup data saved in the computer to the control unit.

The backup and restoration functions can be used for the following files.

⚠ CAUTIOIN

Do not disconnect the cable while backing up or restoring data. If disconnected during data transfer, it will not only be impossible to acquire data correctly, but control unit and computer operation may be adversely affected. Before disconnecting the cable, close the MELFA-3D Vision settings screen.

7.11.1.1. Backup (control unit → computer)

The backup function is used to save information stored inside the control unit to a file on the computer.
By clicking [Maintenance] - [Backup] in the guidance menu at the MELFA-3D Vision setting screen, a Backup screen appears.

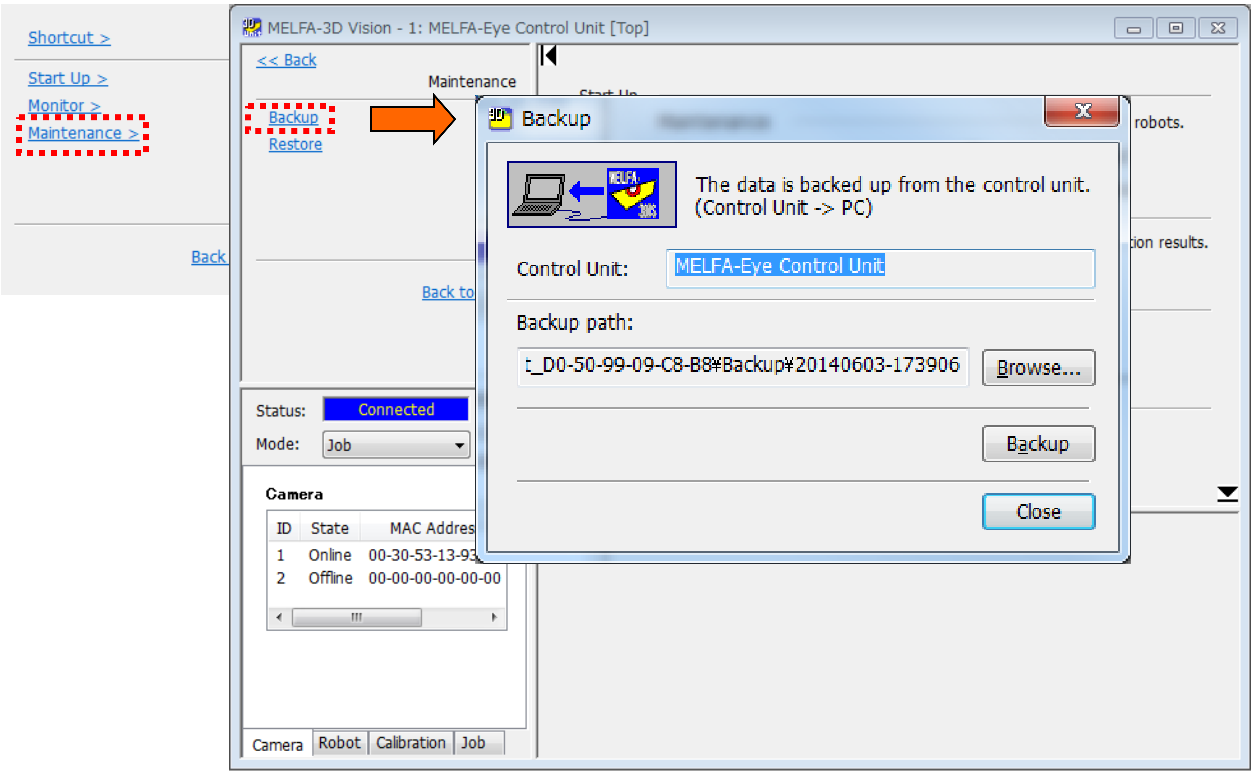


Fig. 7-140 Backup

<u>Specifying the backup location</u>

Click the [Browse] button if necessary to change the backup location. The default location is:
"Folder in which workspace created\Project name\MELFA-3D Vision\Control unit name_MAC address\Backup\Today's date and time"

Performing a backup

By clicking the [Backup] button, a confirmation screen appears. Following confirmation, click [Yes] to start the backup.

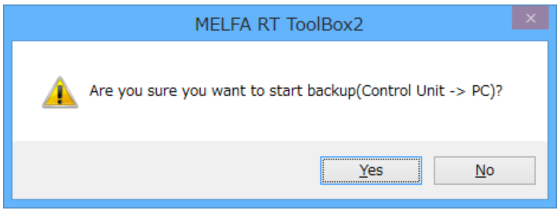


Fig. 7-141 Backup confirmation screen

When the backup is completed, backup data appears under [MELFA-3D Vision] - [Control unit name] in the project tree.

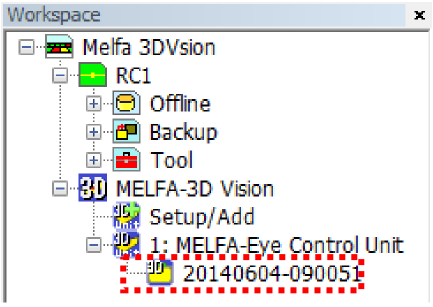


Fig. 7-142 Backed up information display

7.11.1.2. Restoration (computer → control unit)

Information backed up in the computer can be transferred to the control unit.

By clicking [Maintenance] - [Restore] in the guidance menu at the MELFA-3D Vision setting screen, a Restoration screen appears.

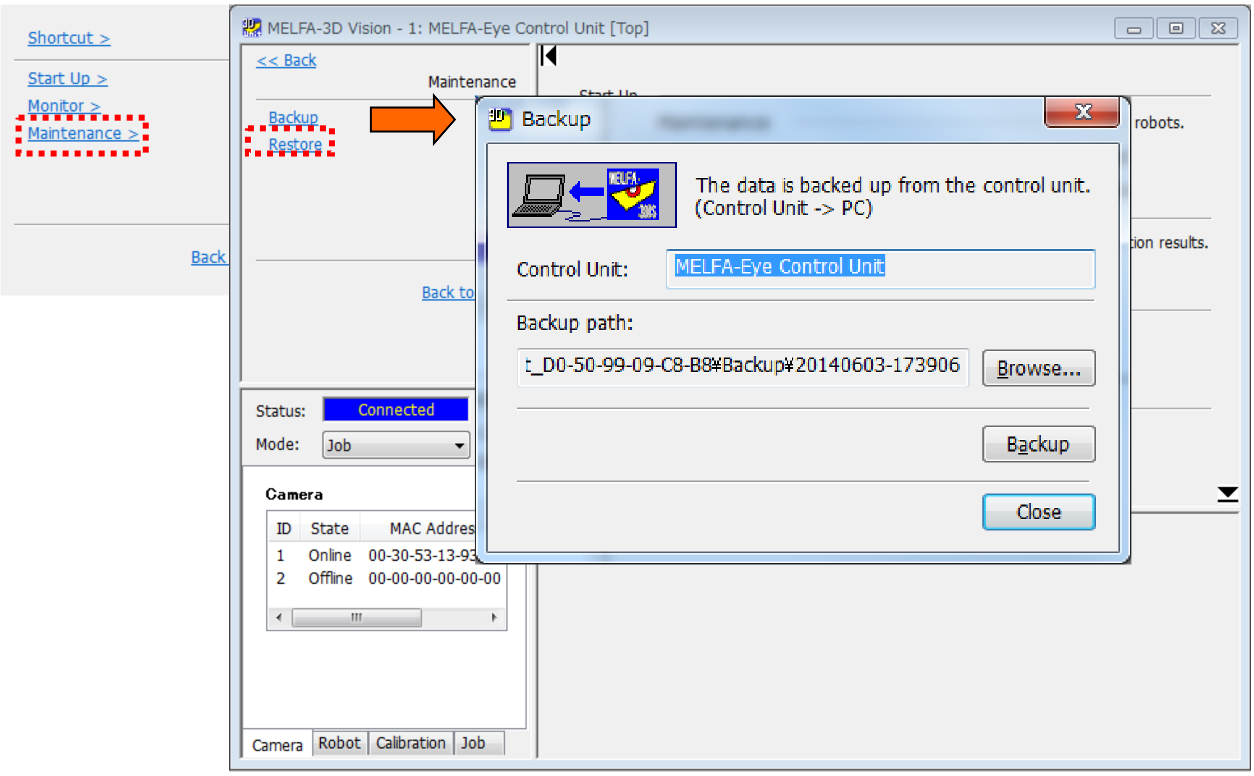


Fig. 7-143 Restoration

Specifying the restoration target
Click the [Browse] button and specify the location of the backup file to be restored.
Performing restoration
By clicking the [Restore] button, a confirmation screen appears. Following confirmation, click [OK] to start the restoration. There is no need to reboot after the restoration is completed.

⚠ CAUTION

If editing or executing a job, end editing or execution before performing the restoration. Not doing so may cause unsuccessful restoration.

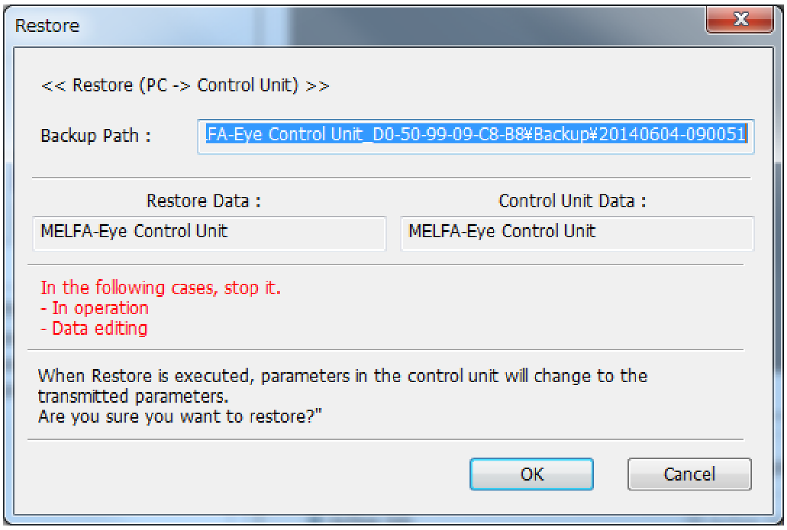


Fig. 7-144 Restoration confirmation screen

7.11.2. Control unit software update

The control unit software can be updated. Contact the manufacturer for the latest software.
By right-clicking [MELFA-3D Vision] - [Control unit name] in the project tree and clicking [Update] in the context menu that appears, the control unit update screen appears.

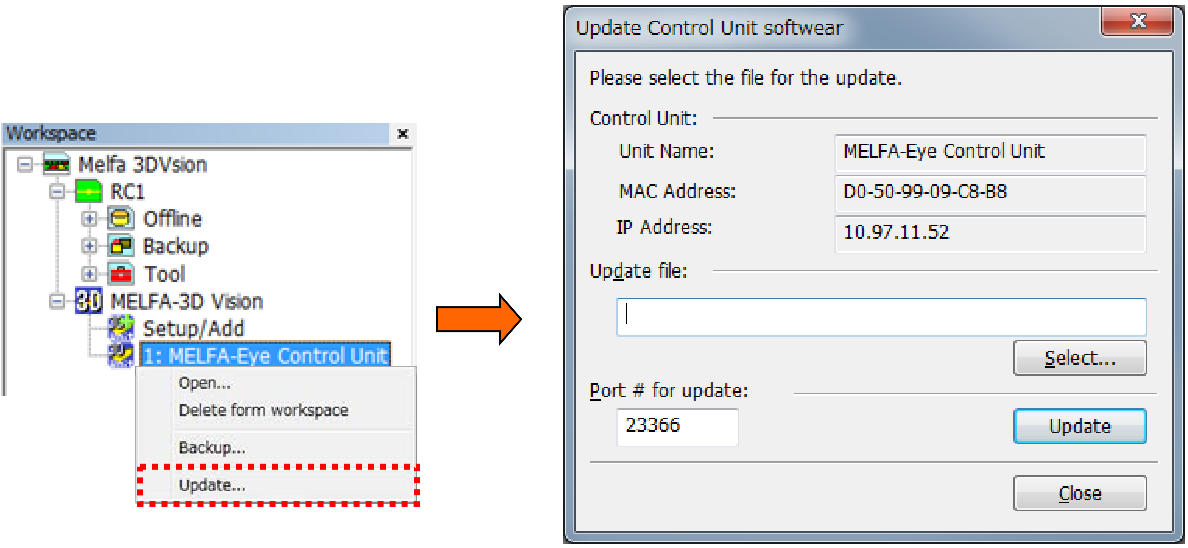


Fig. 7-145 Control unit update

Selecting the update file
Click the [Select] button and then specify the update file.

Performing the update
By clicking the [Update] button, a confirmation screen appears. Following confirmation, click [OK] to start the update.

⚠ CAUTION

If editing or executing a job, end editing or execution before updating.

8. LANGUAGE SPECIFICATIONS

8.1. MELFA-3D Vision Related Commands

Table 8-1: Command list

Command name	Function
V3Open	Connects to MELFA-3D Vision and enables measurement.
V3Close	Disconnects from MELFA-3D Vision.
V3Run	Executes the job.
V3Calib	Transmits calibration information.
V3Calc	Performs calibration.
Dot	Calculates inner product.
ACos	Calculates arc cosine.
ASin	Calculates arc sine.

V3Open

[Function]

Connects to the specified MELFA-3D Vision and enables measurement.

[Syntax]

```
V3Open "<COM No.>"    AS    # <Vision sensor No.>
```

[Term]

<COM No.>: [Character string]

Specifies the communication connection No. in the same way as the Open command.
If using the CRn-7xx controller, "COM1:" cannot be specified because it is occupied by the O/P front RS-232C.
Setting range: "COM2:" to "COM8:"

<Vision sensor No.>: [Constant]

Specify a constant from 1 to 8 (Vision sensor No.). The MELFA-3D Vision unit connected to the COM specified with the <COM No.> is expressed with a number.
Furthermore, since this number is shared with the Open command <File No.>, caution is advised.
Setting range: 1 to 8

[Example]

```
1.  If M_Open(1) <> 2 Then    'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1      'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3.  EndIf
4.  Wait M_Open(1) = 2        'Connect to vision sensor No. 1 and wait until measurement is possible.
```

[Description]

(1) A connection is established to MELFA-3D Vision using the line specified with the <COM No.>.
(2) It is possible to connect to up to seven MELFA-3D Vision units simultaneously. The "Vision sensor No." is used to identify which MELFA-3D Vision unit to communicate with.
(3) If using together with the Open command, the Open command <COM No.>, <File No.>, and <COM No.> for this command are shared. Therefore, it is necessary to use numbers other than those specified with the Open command <COM No.> and <File No.>.

Normal example	Example resulting in error
1. Open "COM1:" As #1 2. V3Open "COM2:" As #2 3. V3Open "COM3:" As #3	1. Open "COM2:" As #1 2. V3Open "COM2:" As #2 ⇒ <COM No.> is used. 3. V3Open "COM3:" As #1 ⇒ <Vision sensor No.> is used.

(4) The communication status with MELFA-3D Vision when this command is executed can be checked with the status variable M_Open. Refer to the M_Open description for details.
(5) Communication stops immediately if the program is aborted while executing this command. It is necessary to reset the program and reboot in order to communicate with MELFA-3D Vision.
(6) If interrupt conditions are established while executing this command, interrupt processing is performed after processing of this command is completed.
(7) The connection is not closed with program End command called with the CallP command, however, the connection is closed with the main program End command. The connection is also closed when the program is reset.

[Related status variable]

Status variable	Description
M_Open	Returns the connection status.

[Related command]

Command	Description
V3Close	Disconnects from MELFA-3D Vision.
V3Run	Starts the program for MELFA-3D Vision.
V3Calib	Acquires calibration images for MELFA-3D Vision.
V3Calc	Performs calibration for MELFA-3D Vision.

[Related parameter]

Parameter name	Description
OPNTOUT	Open command timeout

V3Close

[Function]

Disconnects from the specified MELFA-3D Vision unit.

[Syntax]

```
V3Close    [ [#]<Vision sensor No.> [,[[#]<Vision sensor No.>...]
```

[Term]

<Vision sensor No.> (can be omitted): [Constant]

Specifies the MELFA-3D Vision unit number to be controlled (setting range: 1 to 8).
When omitted, all connections established by the V3Open command or Open command are closed.

[Example]

```
1.  If M_Open(1) <> 2 Then  'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1    'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3.  EndIf
4...
20. V3Close #1              'Disconnect from MELFA-3D Vision connected to COM2.
```

[Description]

(1) Disconnects from the MELFA-3D Vision unit to which a connection was established with the V3Open command.
(2) If the <Vision sensor No.> is omitted, all connections are closed.
(3) If a connection has been already closed, the process proceeds to the next step.
(4) It is possible to connect to up to seven MELFA-3D Vision units simultaneously. Therefore, the <Vision sensor No.> is used to identify the MELFA-3D Vision unit to be disconnected.
(5) If the program is aborted while executing this command, execution is continued until processing of this command is completed.
(6) If the End command is used, all connections established by the V3Open or Open command are closed. However, connections are not closed with End command inside programs called with the CallP command. Furthermore, connections are also closed when resetting the program. Therefore, if the End command is specified or the program is reset, there is no need to close connections using this command.
(7) If interrupt conditions are established while executing this command, interrupt processing is performed after processing of this command is completed.

[Related status variable]

Status variable	Description
M_Open	Returns the connection status.

[Related commands]

Command	Description
V3Open	Connects to MELFA-3D Vision.
V3Run	Starts the program for MELFA-3D Vision.
V3Calib	Acquires calibration images for MELFA-3D Vision.
V3Calc	Performs calibration for MELFA-3D Vision.

V3Run

[Function]

Executes the specified job and saves the result to MELFA-3D Vision. The robot does not receive the result with this command. The result for which the command was executed is stored in M_V3Res.

[Syntax]

```
V3Run   #<Vision sensor No.>, <Job name>, <Workspace ID>, <Measurement flag>, <Recognition flag>
        [, <Recognition target No.>[, <Storage destination No.> [, <Mechanical interface coordinates>]]]
```

[Term]

<Vision sensor No.>: [Constant]
Specifies the MELFA-3D Vision unit number to be controlled (setting range: 1 to 8).

<Job name>: [Character string]
Specifies the name of the job (vision program) to be started.
Only characters '0' to '9', 'A' to 'Z', 'a' to 'z', '-', and '_' can be used, and it must be within 15 characters.

<Workspace ID>: [Integer type]
Specifies the MELFA-3D Vision workspace for which vision processing is performed.
Setting range: 1 to 8

<Measurement execution flag>: [Integer type]
Specifies whether to create a range image.
Setting range: 0 = Don't create, or 1 = Create

<Recognition execution flag>: [Integer type]
Specifies whether to perform image recognition.
Setting range: 0 = Don't perform recognition or 1 = Perform recognition

<Recognition target No.> (can be omitted): [Integer type]
Specifies the recognition target No. (model and recognition parameter corresponding to that model) specified in the workpiece list at MELFA-3D Vision. (For model matching only)
Setting range: 1 to 8
Judged as "1" when omitted.

<Storage destination No.> (can be omitted): [Integer type]
Specifies the number for the area in which the recognition result is stored.
Setting range: 1 to 10 * Judged as "1" when omitted.

If, for example, "2" is specified, the recognition result is stored below.
M_V3Err(2) / M_V3Rslt(2) / M_V3Num(2) / P_V3Pos(2,1) to (2,10) / M_V3Dat1(2,1) to (2,10) / M_V3Dat1(2,1) to (2,10)

<Mechanical interface coordinates> (can be omitted): [Position type]
Specifies the mechanical interface position (position of mechanical interface surface on arm tip) required for MELFA-3D Vision to convert the recognized workpiece positions in the base coordinate system (coordinate system with robot installation position as reference).
When omitted, the current position is used, and the position for the coordinate system excluding the tool length and base coordinate settings is used.
The coordinates sent to MELFA-3D Vision are (X, Y, Z, A, B, C, L1, L2) and (FL1, FL2), however, the only coordinates applicable to MELFA-3D Vision are (X, Y, Z, A, B, C).

[Example]

```
1.  If M_Open(1) <> 2 Then   'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1     'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
2.  EndIf
4.  Wait M_Open(1) = 2       'Connect to vision sensor No. 1 and wait until measurement is possible.
5.  Mov PCap                 'Move to measurement position.
6.  V3Run #1, "TEST", 5, 1, 1 'Execute job name "TEST".
7.  *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1 'Wait until result received from MELFA-3D Vision.
8.  If M_V3Rslt(1) <> 0 Then Error 9100'Output error 9100 if unsuccessful.
9...
15. V3Close #1               'Disconnect from MELFA-3D Vision connected to COM2.
```

[Description]

(1) Executes the job for the specified MELFA-3D Vision unit.
(2) This command prompts a move to the next step after sending a measurement processing command to MELFA-3D Vision.
(3) Communication stops immediately if the program is aborted while executing this command.
(4) Since MELFA-3D Vision writes the recognition result to a status variable, the applicable status variable should be used after checking M_V3Rslt().
(5) If interrupt conditions are established while executing this command, interrupt processing is performed after processing of this command is completed.
(6) If the timeout time specified in parameter "V3TMOUT" is exceeded, an 8632 error occurs.
By restarting the robot program following the occurrence of this error, a request is sent to MELFA-3D Vision again.

[Related status variables]

Status variable	Description
M_V3Rslt	Returns the image processing execution result.
M_V3Num	Returns the recognition count.
P_V3Pos	Returns the position of the recognized workpiece.

[Related commands]

Command	Description
V3Open	Connects to MELFA-3D Vision.
V3Close	Disconnects from MELFA-3D Vision.
V3Calib	Acquires calibration images for MELFA-3D Vision.
V3Calc	Performs calibration for MELFA-3D Vision.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

V3Calib

[Function]

Transmits calibration image acquisition requests.

[Syntax]

```
V3Calib   #<Vision sensor No.>, <Posture ID> [, <Storage destination No.>]
```

[Term]

<Vision sensor No.>: [Constant]
Specifies the MELFA-3D Vision unit number to be controlled (setting range: 1 to 8).

<Posture ID>: [Integer type]
Images at eight locations are required to perform calibration. Move to the position for each location and specify the respective posture ID.
Setting range: 1 to 8

<Storage destination No.> (can be omitted): [Integer type]
Specifies the number for the area in which the recognition result is stored.
Setting range: 1 to 10 * Judged as "1" when omitted.

If, for example, "5" is specified, the recognition result is stored below.
M_V3Err(5) / M_V3Rslt(5)

[Example]

```
1.  If M_Open(1) <> 2 Then   'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1     'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3.  EndIf
4.  Wait M_Open(1) = 2       'Connect to vision sensor No. 1 and wait until measurement is possible.
5...
10. For MCnt = 1 To 8        ‘Result receipt
11. Mov PCALB(MCnt)          ‘Move to calibration position.
12. Dly 1
13. V3Calib #1, MCnt         ‘Send calibration image acquisition request to MELFA-3D Vision.
14. *Loop3:If M_V3Rslt(3) < 0 Then Goto *Loop3     ‘Wait for response from MELFA-3D Vision.
15. If M_V3Rslt(3) <> 0 Then Error 9100            'Output error 9100 if unsuccessful.
16. Next MCnt
17...
25. V3Calc #1, 5       ‘Perform calibration.
26. *Loop3:If M_V3Rslt(5) < 0 Then Goto *Loop4     ‘Wait for response from MELFA-3D Vision.
27. If M_V3Rslt(5) <> 0 Then Error 9101            'Output error 9101 if unsuccessful.
28...
35. V3Close #1               'Disconnect from MELFA-3D Vision connected to COM2.
```

[Description]

(1) A calibration image acquisition request is sent to the specified MELFA-3D Vision unit.

(2) Since MELFA-3D Vision returns an immediate reply statement after receiving the request, it is necessary to check M_V3Rslt at the next step. If there is no response even after the timeout time specified in parameter "V3TMOUT" is exceeded, an error occurs.
By restarting the robot program following the occurrence of this error, a request is sent to MELFA-3D Vision again.

(3) If interrupt conditions are established while executing this command, interrupt processing is performed after processing of this command is completed.

[Related status variable]

Status variable	Description
M_V3Rslt	Returns the image processing execution result.

[Related commands]

Command	Description
V3Open	Connects to MELFA-3D Vision.
V3Close	Disconnects from MELFA-3D Vision.
V3Run	Starts the program for MELFA-3D Vision.
V3Calc	Performs calibration for MELFA-3D Vision.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

V3Calc

[Function]

Requests to perform calibration measurement.

[Syntax]

```
V3Calc   #<Vision sensor No.>, [, <Storage destination No.>]
```

[Term]

<Vision sensor No.>: [Constant]

Specifies the MELFA-3D Vision unit number to be controlled (setting range: 1 to 8).

<Storage destination No.> (can be omitted): [Integer type]

Specifies the number for the area in which the recognition result is stored.

Setting range: 1 to 10 * Judged as "1" when omitted.

If, for example, "5" is specified, the recognition result is stored below.

M_V3Rslt(5)

[Example]

```
1.  If M_Open(1) <> 2 Then   'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1     'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3.  EndIf
4.  Wait M_Open(1) = 2       'Connect to vision sensor No. 1 and wait until measurement is possible.
5...
6.  For MCnt = 1 To 8        ‘Result receipt
7.  Mov PCALB(MCnt)          ‘Move to calibration position.
8.  Dly 1
9.  V3Calib #1, MCnt         ‘Send calibration image acquisition request to MELFA-3D Vision.
10. *Loop3:If M_V3Rslt(3) < 0 Then Goto *Loop3     ‘Wait for response from MELFA-3D Vision.
11. If M_V3Rslt(3) <> 0 Then Error 9100            'Output error 9100 if unsuccessful.
12. Next MCnt
13...
20. V3Calc #1, 5     ‘Perform calibration.
21. *Loop3:If M_V3Rslt(5) < 0 Then Goto *Loop4     ‘Wait for response from MELFA-3D Vision.
22. If M_V3Rslt(5) <> 0 Then Error 9101            'Output error 9101 if unsuccessful.
23...
30. V3Close #1               'Disconnect from MELFA-3D Vision connected to COM2:.
```

[Description]

(1) A calibration measurement request is sent to the specified MELFA-3D Vision unit.

(2) Since MELFA-3D Vision returns an immediate reply message after receiving the request, it is necessary to check M_V3Rslt and M_V3Err at the next step. If there is no response even after the timeout time specified in parameter "V3TMOUT" is exceeded, an error occurs.
By restarting the robot program following the occurrence of this error, a request is sent to MELFA-3D Vision again.

(3) If interrupt conditions are established while executing this command, interrupt processing is performed after processing of this command is completed.

[Related status variable]

Status variable	Description
M_V3Rslt	Returns the image processing execution result.

[Related commands]

Command	Description
V3Open	Connects to MELFA-3D Vision.
V3Close	Disconnects from MELFA-3D Vision.
V3Run	Starts the program for MELFA-3D Vision.
V3Calib	Acquires calibration images for MELFA-3D Vision.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

Dot

[Function]

Converts two specified position coordinates to unit vectors, and returns the result of inner product.

[Syntax]

```
<Numeric variable> = Dot( <Element 1>, <Element 2> [, <Vector direction designation>] )
```

[Term]

<Numeric variable>: [Double-precision real number]

Specifies a numeric variable to be substituted by the inner product result.
The specified position variables are converted to vectors, and the inner product result is returned with those vectors changed to unit vectors.
Range: -1.0 to +1.0

<Element 1>: [Position variable]

Specifies the first target information to obtain the inner product.
With 3D vision sensor model matching, for example, the position coordinates used when teaching are specified.

<Element 2>: [Position variable]

Specifies the second target information to obtain the inner product.
With 3D vision sensor model matching, for example, the position coordinates used to grip the workpiece obtained from the recognition result are specified.

<Vector direction designation> (can be omitted): [Numeric variable]

Specifies which axis direction to use as the vector for the position coordinates specified with elements 1 and 2.
Setting range: 0 = position coordinate Z direction / 1 = position coordinate Y direction / 2 = position coordinate X direction
* Judged as a Z direction of 0 when omitted.

(Example) If 2, it is judged as a +X direction position coordinate vector.

Argument types that can be used

<Numeric variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	Δ	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, Δ: Decimals are rounded up (do not use), ×: Cannot be used (a syntax error occurs on registration)

<Element 1> <Element 2>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	×	×	×	○	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

<Vector direction designation>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	○	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

[Return value description]

Converts the specified <Element 1> and <Element 2> to unit vectors, and returns the inner product result. The relationship between the <Element 1> and <Element 2> vectors is as follows depending on the inner product result value.

0 to 1.0: acute angle
0: perpendicular
-1.0 to 0: obtuse angle

[Example]

1. MDot = Dot(PTeach, PCatch) 'Substitute PTeach and PCatch inners product result in MDot.

[Description]

(1) Position data for the specified <Element 1> and <Element 2> are converted to the direction vectors specified in <Vector direction designation>. Those vectors are then converted to unit vectors, and the inner product result for the converted vectors is returned.
   * The inners product result for the single vector is returned in order to perform a comparison under identical conditions for all vectors.

(2) The <Vector direction designation> can be omitted. If omitted, it is judged as the hand coordinate system +Z direction, and the vectors for <Element 1> and <Element 2> are calculated. Then, the inner product of the vectors is then obtained.

(3) If using a 5-axis mechanism or 4-axis mechanism, the inner product result can be used by setting the <Vector direction designation> to other than the Z direction (0) with the flange facing straight downward.

ACos (Arc cosine)

[Function]
Returns an arc cosine value from the specified cosine value (numerical value).

[Syntax]

```
<Numeric variable> = ACos( <Cosine value> )
```

[Term]
<Numeric variable>: [Double-precision real number]
Specifies the numeric variable substituted by the obtained arc cosine value.
Range: 0 to π
<Cosine value>: [Double-precision real number]
Specifies the cosine value.
Setting range: -1.0 to +1.0

Argument types that can be used
<Numeric variable> <Cosine value>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	Δ	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, Δ: Decimals are rounded up (do not use), ×: Cannot be used (a syntax error occurs on registration)

[Return value description]
Returns an arc cosine value for the specified <Cosine value>.

[Example]
1. MRad = ACos(0.6) 'Substitute an arc cosine value of 0.6 (0.927295218001612 rad) in MRad.

[Description]
(1) Returns an arc cosine value for the specified <Cosine value>.

ASin (Arc sine)

[Function]

Returns an arc sine value from the specified sine value (numerical value).

[Syntax]

```
<Numeric variable> = ASin( <Sine value> )
```

[Term]

<Numeric variable>: [Double-precision real number]

Specifies the numeric variable substituted by the obtained arc sine value.
Range: $-\pi/2$ to $+\pi/2$

<Sine value>: [Double-precision real number]

Specifies the sine value.
Setting range: -1.0 to +1.0

Argument types that can be used

<Numeric variable> <Sine value>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	Δ	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, Δ: Decimals are rounded up (do not use), ×: Cannot be used (a syntax error occurs on registration)

[Return value description]

Returns an arc sine value for the specified <Sine value>.

[Example]

1. MRad = ASin(-0.4)　'Substitute an arc sine value of -0.4 (-0.411516846067488 rad) in MRad.

[Description]

(1) Returns an arc sine value for the specified <Sine value>.

8.2. MELFA-3D Vision Related Status Variables

Table 8-2: Robot (system) status variable list

Variable name	Array qty	Function	Attributes Note 1	Data type
M_Open(m) m = File No.	File No. 1 to 8	Returns the MELFA-3D Vision connection status. -1: Not connected (default) 1: Connecting (connected and transmitting/ receiving commands) 2: Connection completed	R	Integer type
M_V3Rslt(n) n = Storage destination No.	Storage destination No. 1 to 10	The command result is stored in MELFA-3D Vision. -2: Executing job -1: Initial value (automatic initialization when transmission successful) 0: Job execution successful 1: Unsuccessful 2: Argument quantity error 3: Value outside range 4: Specified name already used 5: Image acquisition unsuccessful 6: Measurement unsuccessful 7: Recognition unsuccessful 8: Illegal name 9: Being used 10: Upper limit reached 11: Unable to use 50: Work in progress and not available 51: Unable to start update tool 52: Unable to exit vision system 53: Unable to start vision system 54: Illegal update file 9999: Other request operation failure (general error) (1) Initialized to "-1" when command V3Open/V3Close is executed. (2) Initialized to "-1" when command V3Run/ V3Calib/V3Calc is executed, and the above value is stored depending on the response from MELFA-3D Vision. (3) When there is an error on the camera head, the value “6: Fail to measure” is stored. (Please refer Section 10.3 Q&A).	R/W Note 2	Integer type
M_V3Num(n) n = Storage destination No.	Storage destination No. 1 to 10	The recognized hand insertion position candidate quantity (model-less recognition) or the workpiece quantity (model matching recognition) is stored. 0 to 50 Note 3	R/W Note 2	Integer type
P_V3Pos(n, m) n = Storage destination No. m=Data number	Storage destination No. 1 to 10 Data number 1 to 50 Note 3	The recognized hand insertion position (model-less recognition) or the workpiece position (model matching recognition) is stored. (Max. 50) Note 3 The applicable coordinates are "XYZABC". Zero is entered for all additional axis information and structure flags. Please note that with model-less recognition, the positions in the base coordinate system are stored for X, Y, and Z, and the rotation angle around the Z-axis in the camera coordinate system is stored for C.	R/W Note 2	Position type

Variable name	Array qty	Function	Attributes Note 1	Data type
M_V3Dat1(n, m) n = Storage destination No. m=Index number	Storage destination No. 1 to 10 Index number 1 to 50 Note 3	The evaluation index for the recognized result is stored. (Index No.1 = workpiece residual amount)	R/W Note 2	Real number type
M_V3Dat2(n, m) n = Storage destination No. m=Index number	Storage destination No. 1 to 10 Data number 1 to 50 Note 3	The recognition scores for the recognized hand insertion position (model-less recognition) and workpiece position (model matching recognition) are stored. (Max. 50) Note 3	R/W Note 2	Real number type

Note 1: R...Read only, R/W...Read and write both possible
Note 2: Writing is possible because data is written from the control unit.
Note 3: The upper limits of the recognition number and the data / index number change depending on the software version of the controller.

- Ver.R6e/S6e or later: Up to 50
- Ver.R6e/S6e or earlier: Up to 10

M_Open

[Function]

Represents the (MELFA-3D Vision) connection status for the specified file.

[Syntax]

```
<Numeric variable> = M_Open[(<File No.>)]
```

[Term]

<Numeric variable>

Specifies a numeric variable to be substituted by the result.

<File/Vision sensor No.>(can be omitted): [Integer type]

Specifies a constant of the file (vision sensor) number (1 to 8) specified with the Open/V3Open command.

Judged as "1" when omitted.

Argument types that can be used

<Numeric variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	○	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

<File No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

[Return value description]

-1: Not connected
0: Connecting
1: Connection completed
2: Measurement possible (for MELFA-3D Vision only)

[Example]

```
1.  If M_Open(1) <> 2 Then   'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1     'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3.  EndIf
4.  Wait M_Open(1) = 2       'Wait until vision sensor No. 1 is capable of measurement.
5...
10. V3Close #1               'Disconnect from MELFA-3D Vision connected to COM2:.
```

[Description]

(1) Represents the status of the connection with MELFA-3D Vision established with the V3Open command.

(2) The initial value is "1". When the V3Open command is executed, the value becomes "1" during the connection processing. Then, the value becomes "1" when connection processing is completed, and finally it becomes "2" when measurement is possible.

[Related commands]

Command	Description
V3Open	Connects to MELFA-3D Vision.
V3Close	Disconnects from MELFA-3D Vision.

[Related status variable]

Command	Description
M_NvOpen	Returns the status of the connection with the network vision sensor.

[Related parameter]

Parameter name	Description
OPNTOUT	Open command timeout

M_V3Rslt

[Function]

The processing result corresponding to the request sent to MELFA-3D Vision is stored.

[Syntax]

```
<Numeric variable> = M_V3Rslt[(<Storage destination No.>)]
```

[Term]

<Numeric variable>

Specifies a numeric variable to be substituted by the result.

<Storage destination No.> (can be omitted): [Integer type]

Specifies the storage destination (No. 1 to 10) specified with the V3Run/V3Calib/V3Calc command.

Argument types that can be used

<Numeric variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	○	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

<Storage destination No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

[Return value description]

-2: Executing job
-1: Default (automatic initialization when transmission successful)
0: Job execution successful
1: Unsuccessful
2: Argument quantity error
3: Value outside range
4: Specified name already used
5: Image acquisition unsuccessful
6: Measurement unsuccessful
7: Recognition unsuccessful
8: Illegal name
9: Being used
10: Upper limit reached
11: Unable to use
50: Work in progress and not available
51: Unable to start update tool
52: Unable to exit vision system
53: Unable to start vision system
54: Illegal update file

[Example]

1. If M_Open(1) <> 2 Then 'If vision sensor No. 1 is not capable of measurement
2. V3Open "COM2:" As #1 'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3. EndIf
4. Wait M_Open(1) = 2 'Connect to vision sensor No. 1 and wait until measurement is possible.
5. Mov PCap 'Move to measurement position.
6. V3Run #1, "TEST", 5, 1, 1 'Execute job name "TEST".
7. *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1 'Wait until result received from MELFA-3D Vision.
8. If M_V3Rslt(1) <> 0 Then Error 9100 'Output error 9100 if unsuccessful.

9...

20. V3Close #1 'Disconnect from MELFA-3D Vision connected to COM2:.

[Description]

(1) Stores the result from MELFA-3D Vision when the V3Run/V3Calib/V3Calc command is executed.
(2) "-1" is stored when starting up. The value is initialized to "-1" each time a command is executed.

[Related commands]

Command	Description
V3Run	Starts the program for MELFA-3D Vision.
V3Calib	Acquires calibration images for MELFA-3D Vision.
V3Calc	Performs calibration for MELFA-3D Vision.

[Related status variables]

Status variable	Description
M_V3Num	Returns the recognition count.
P_V3Pos	Returns the position of the recognized workpiece.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

M_V3Num

[Function]

The recognized hand insertion position candidate quantity (model-less recognition) or the workpiece quantity (model matching recognition) is stored.

Note: The upper limit of the recognition number changes depending on the software version of the controller.

- Ver.R6e/S6e or later: Up to 50
- Ver.R6e/S6e or earlier: Up to 10

[Syntax]

```
<Numeric variable> = M_V3Num[(<Storage destination No.>)]
```

[Term]

<Numeric variable>

Specifies a numeric variable to be substituted by the result.

<Storage destination No.> (can be omitted): [Integer type]

Specifies the storage destination (No. 1 to 10) specified with the V3Run command.

Argument types that can be used

<Numeric variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	○	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

<Storage destination No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

[Example]

```
1. If M_Open(1) <> 2 Then   'If vision sensor No. 1 is not capable of measurement
2. V3Open "COM2:" As #1     'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3. EndIf
4. Wait M_Open(1) = 2       'Connect to vision sensor No. 1 and wait until measurement is possible.
5. Mov PCap                 'Move to measurement position.
6. V3Run #1, "TEST", 5, 1, 1 'Execute job name "TEST".
7. *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1   'Wait until result received from MELFA-3D Vision.
8. If M_V3Rslt(1) <> 0 Then Error 9100          'Output error 9100 if unsuccessful.
9. MNum = M_V3Num(1)
   'Store recognition result in MNum.
10. If MNum = 0 Then Goto *FIN                  'Recognition count is 0 and therefore finished.
11...
15. *FIN
16...
20. V3Close #1              'Disconnect from MELFA-3D Vision connected to COM2:.
```

[Description]

(1) The hand insertion position candidate quantity (model-less recognition) or the workpiece quantity (model matching recognition) recognized when executing the V3Run command is stored.

(2) "0" is stored when starting up. The value is initialized to "0" each time a command is executed.

[Related command]

Command	Description
V3Run	Starts the program for MELFA-3D Vision.

[Related status variables]

Status variable	Description
M_V3Rslt	Returns the image processing execution result.
P_V3Pos	Returns the position of the recognized workpiece.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

P_V3Pos

[Function]

The hand insertion position (model-less recognition) or the workpiece position (model matching recognition) recognized by MELFA-3D Vision is stored.

[Syntax]

```
<Position variable> = P_V3Pos(<Storage destination No.>, <Data No.>)
```

[Term]

<Position variable>

Specifies a position variable to be substituted by the result.

<Storage destination No.>: [Integer type]

Specifies the storage destination (No. 1 to 10) specified with the V3Run command.

<Data No.>: [Integer type]

Specifies the number (1 to 50) in which recognized data is stored.

Note: The upper limit of the data number changes depending on the software version of the controller.

- Ver.R6e/S6e or later: Up to 50
- Ver.R6e/S6e or earlier: Up to 10

Argument types that can be used

<Position variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	Δ	×	×
Variable	×	×	×	○	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (× for substitution destination from status variable)

<Storage destination No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

<Data No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

[Return value description]

Model-less recognition: Base coordinate system positions for X, Y, and Z, and rotation angle around Z-axis in camera coordinate system for C (-90º ≥C < 90º)

[Example]

```
1. If M_Open(1) <> 2 Then   'If vision sensor No. 1 is not capable of measurement
2. V3Open "COM2:" As #1     'Connect to MELFA-3D Vision connected to COM2: and set number to 1.
3. EndIf
```

```
4.  Wait M_Open(1) = 2          'Connect to vision sensor No. 1 and wait until measurement is possible.
5.  Mov PCap                    'Move to measurement position.
6.  V3Run #1, "TEST", 5, 1, 1   'Execute job name "TEST".
7.  *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1     'Wait until result received from MELFA-3D Vision.
8.  If M_V3Rslt(1) <> 0 Then Error 9100            'Output error 9100 if unsuccessful.
9.  MNum = M_V3Num(1)                              'Store recognition result in MNum.
10. If MNum = 0 Then Goto *FIN                     'Recognition count is 0 and therefore finished.
11. PRcg = P_V3Pos(1,1)         'Store recognized position in PGet.
12. PRot = P_Zero
13. PRot.C = PRcg.C             'Extract C component from recognition result.
14. PHnd = P_Zero
15. If PRot.C>0 Then PHnd.C = -90DEG Else PHnd.C = +90DEG
16. PAp.X = PRcg.X
17. PAp.Y = PRcg.Y
18. PAp.Z = 150                 'Substitute height over parts supply box.
19. PAp.A = PCap.A              'Align with measurement position posture.
20. PAp.B = PCap.B
21. PAp.C = PCap.C
22. PAp = Pap * PRot            'Calculate hand posture alignment position.
23. PGet = PAp
24. PGet.Z = PRcg.Z - 20        'Subtract amount of claw thrust amount (roughly three fourths of
    workpiece height).
25. Mvs Pap                     'Hand posture alignment
26. Mvs PGet                    'Entry and gripping
27. Dly 0.5
28. HClose 1
29. Dly 0.5
30. Mvs PAp
31...
40. *FIN
41...
50. V3Close #1                  'Disconnect from MELFA-3D Vision connected to COM2:.
```

[Description]

(1) The hand insertion position (model-less recognition) or the workpiece position (model matching recognition) when executing the V3Run command is stored. The recognition score is stored in order from the higher score from data No. = 1.
(2) P_Zero is stored when starting up. The value is initialized to P_Zero each time a command is executed.
(3) If M_V3Rslt is not 0, or if M_V3Num is 0, and illegal value has been stored, do not use the value.

[Related command]

Command	Description
V3Run	Starts the program for MELFA-3D Vision.

[Related status variables]

Status variable	Description
M_V3Rslt	Returns the image processing execution result.
M_V3Num	Returns the recognition count.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

M_V3Dat1

[Function]

The evaluation index for the result recognized by MELFA-3D Vision is stored.

[Syntax]

```
<Numeric variable> = M_V3Dat1(<Storage destination No.>, <Index No.>)
```

[Term]

<Numeric variable>

Specifies a numeric variable to be substituted by the result.

<Storage destination No.>: [Integer type]

Specifies the storage destination (No. 1 to 10) specified with the V3Run command.

<Index No.>: [Integer type]

Specifies the index number (1 to 50) to be referenced.

Note: The upper limit of the index number changes depending on the software version of the controller.

- Ver.R6e/S6e or later: Up to 50
- Ver.R6e/S6e or earlier: Up to 10

1: Workpiece residual amount [%] (range: 0 to 100) * Model-less recognition only

Note: Under the principles of measurement, range measurement of the area in the shadow of the workpiece is not possible, adversely affecting accurate calculation of the residual amount. Use the workpiece residual amount not as an absolute value, but as a guideline.

2 to 9: Reserved for system

Argument types that can be used

<Numeric variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	○	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

<Storage destination No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

<Data No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

[Example]

```
1.  If M_Open(1) <> 2 Then      'If vision sensor No. 1 is not capable of measurement
2.  V3Open "COM2:" As #1        'Connect to vision sensor connected to COM2: and set number to 1.
3.  EndIf
4.  Wait M_Open(1) = 2          'Connect to vision sensor No. 1 and wait until measurement is possible.
5.  V3Run #1, "TEST", 5, 1, 1 'Execute job name "TEST".
6.  *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1  'Wait until result received from vision sensor.
7.  If M_V3Rslt(1) <> 0 Then Error 9100+M_V3Err(1) ‘If unsuccessful, add return value to 9100 and
    output error.
8.  MNum = M_V3Num(1)           'Store recognition result in MNum.
9.  MData1 = M_V3Dat1(1,1)      ‘Acquire workpiece residual amount.
10...
30. V3Close #1                  'Disconnect from vision sensor connected to COM2:.
```

[Description]

(1) The evaluation index for the recognized result is stored. Specify the evaluation index to be referenced with an index number.
(2) "0" is stored when starting up. The value is initialized to "0" each time a command is executed.

[Related command]

Command	Description
V3Run	Starts the program for MELFA-3D Vision.

[Related status variables]

Status variable	Description
M_V3Err	Returns a response statement return value.
M_V3Rslt	Returns the image processing execution result.
M_V3Num	Returns the recognition count.
P_V3Pos	Returns the position of the recognized workpiece.
M_V3Dat2	Returns the recognition score.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

M_V3Dat2

[Function]

The recognition scores for the hand insertion position (model-less recognition) or the workpiece position (model matching recognition) recognized by MELFA-3D Vision is stored.

[Syntax]

<Numeric variable> = M_V3Dat2(<Storage destination No.>, <Data No.>)

[Term]

<Numeric variable>

Specifies a numeric variable to be substituted by the result.

<Storage destination No.>: [Integer type]

Specifies the storage destination (No. 1 to 10) specified with the V3Run command.

<Data No.>: [Integer type]

Specifies the number (1 to 50) to which recognized data is stored.

Note: The upper limit of the data number changes depending on the software version of the controller.

- Ver.R6e/S6e or later: Up to 50
- Ver.R6e/S6e or earlier: Up to 10

Argument types that can be used

<Numeric variable>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	×	×	×	×	×	×
Variable	○	○	○	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration)

<Storage destination No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

<Data No.>

	Numeric type			Position type	Joint type	Character string type
	Integer	Real number	Double-precision real number			
Constant	○	Δ	Δ	×	×	×
Variable	○	Δ	Δ	×	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

○: Can be used, ×: Cannot be used (a syntax error occurs on registration), Δ (rounded off to integer values)

[Example]

```
1. If M_Open(1) <> 2 Then      'If vision sensor No. 1 is not capable of measurement
2. V3Open "COM2:" As #1        'Connect to vision sensor connected to COM2: and set number to 1.
3. EndIf
4. Wait M_Open(1) = 2          'Connect to vision sensor No. 1 and wait until measurement is possible.
5. V3Run #1, "TEST", 5, 1, 1 'Execute job name "TEST".
6. *Loop1:If M_V3Rslt(1) < 0 Then Goto *Loop1  'Wait until result received from vision sensor.
```

7. If M_V3Rslt(1) <> 0 Then Error 9100+M_V3Err(1) ‘If unsuccessful, add return value to 9100 and output error.
8. MNum = M_V3Num(1) 'Store recognition result in MNum.
9. MData1 = M_V3Dat2(1,1) ‘Acquire recognition score for first recognized workpiece.
10...
30. V3Close #1 'Disconnect from vision sensor connected to COM2:.

[Description]

(1) The hand insertion position (model-less recognition) or the workpiece position (model matching recognition) when executing the V3Run command is stored. The recognition score is stored in order from the higher score from data No. = 1.
Please note that with model-less recognition, the higher the recognition score the better, and with model matching recognition, the lower the score the better.

(2) "0" is stored when starting up. The value is initialized to "0" each time a command is executed.

[Related command]

Command	Description
V3Run	Starts the program for MELFA-3D Vision.

[Related status variables]

Status variable	Description
M_V3Err	Returns a response statement return value.
M_V3Rslt	Returns the image processing execution result.
M_V3Num	Returns the recognition count.
P_V3Pos	Returns the position of the recognized workpiece.
M_V3Dat1	Returns the evaluation index.

[Related parameter]

Parameter name	Description
V3TMOUT	Communication timeout time

9. PARAMETER SPECIFICATIONS

9.1. MELFA-3D Vision Related Robot Parameter List

The following table shows a list of MELFA-3D Vision related robot parameters.

Table 9-1: MELFA-3D Vision related robot parameter list

Parameter	Parameter name	Array qty No. of characters	Description	Default setting
Controller IP address	NETIP	Character string 1	Specifies the robot controller IP address.	(D type) 192.168.0.20 (Q type) 192.168.100.1
Server designation	NETMODE	Integer 9	Specifies whether to set the robot controller as a server or a client. 1: Server/0: Client * When using MELFA-3D Vision, specify "0: Client".	1, 1, 1, 1, 1, 1, 1, 1, 1
Protocol	CPRCE** ** = OPT No. (11 to 19)	Integer 1	Specifies the protocol. 0: Nonprocedural/1: Procedural/2: Data link * MELFA-3D Vision and robots are connected by "2: Data link".	0
Open command timeout	OPNTOUT	Real number 1	Specifies the Open command timeout time. Unit: sec * Open command processing is included in the V3Open command.	3.0
3D Vision communication timeout time	V3TMOUT	Integer 1	Specifies the timeout time when no reply is received after transmitting a command from the robot to MELFA-3D Vision. Unit: sec	3

10. TROUBLESHOOTING

10.1. MELFA-3D Vision Related Error List

The following error numbers consist of four digits plus 5 digits. The first four digits appear on the operation panel and the teaching pendant. The latter five digits can be checked in the RT ToolBox2 error details display.

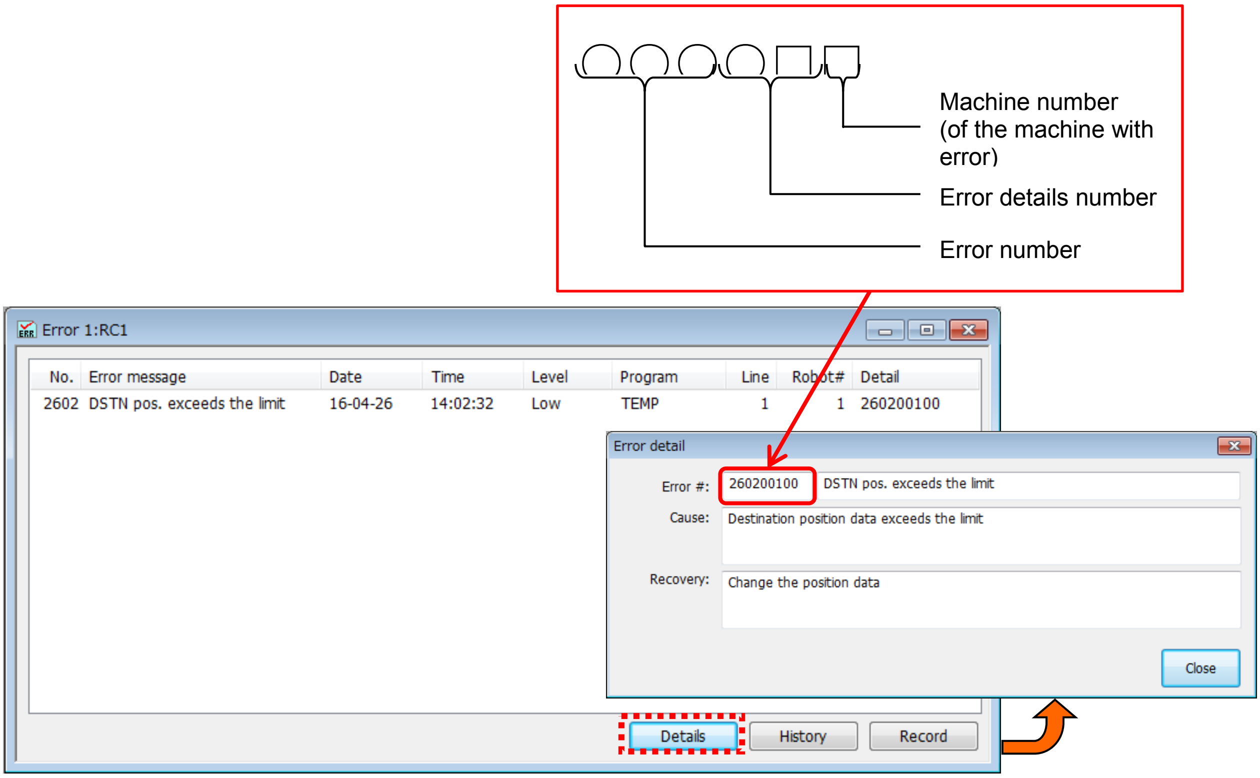


Fig. 10-1 Error details

Table 10-1: Error list

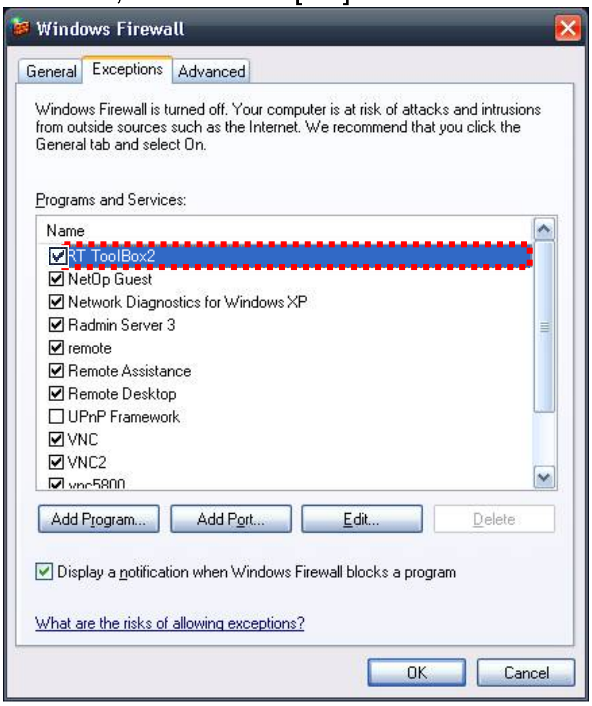
Error No.	Error details
L_3110_00000	Arg. value range over
L_3120_00000	No. of arg. is over
L_3130_00000	COM file is already opened
L_3142_00000	Cannot open COM line
L_3143_00000	V3OPEN command not executed
L_3287_00000	Cannot execute (ERROR ALWAYS)
L_3810_00000	Different argument type
L_4220_00000	Syntax error
L_8610_00000	The communication is abnormal
L_8621_00000	Vision program name is abnormal
L_8632_00000	The vision is a time-out

10.2. MELFA-3D Vision Related Error Details

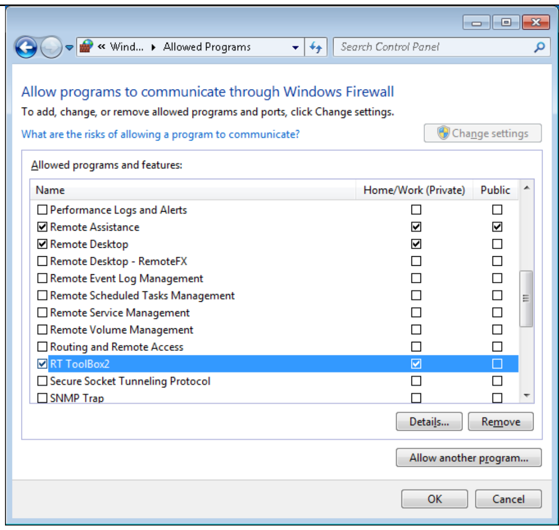
Table 10-2 Error details

Error No. First 4 digits	Error No. Latter 5 digits	Error cause and countermeasure	
L3110	00000	Error message	Arg. value range over
		Cause	The argument value lies outside the range.
		Countermeasure	Check the argument range and set a correct value.
L3120	00000	Error message	No. of argument is over
		Cause	The number of arguments is incorrect.
		Countermeasure	Check the quantity of arguments and set a correct value.
L3130	00000	Error message	COM file is already opened
		Cause	Opening of a file already opened was attempted.
		Countermeasure	Check the file No. and re-execute.
L3142	00000	Error message	Cannot open COM line
		Cause	The communication line cannot be opened.
		Countermeasure	Check the communication No. and re-execute.
L3143	00000	Error message	V3OPEN command not executed
		Cause	The required command has not been executed.
		Countermeasure	Check the specified file No.
L3287	00000	Error message	Cannot execute (ERROR ALWAYS)
		Cause	The command cannot be used when the start conditions are ERROR or ALWAYS.
		Countermeasure	Correct the program.
L3810	00000	Error message	Different argument type
		Cause	The argument type is different.
		Countermeasure	Specify a correct argument.
L4220	00000	Error message	Syntax error
		Cause	There is an error in the syntax of the input command statement.
		Countermeasure	Check the content and re-input a correct syntax.
L8610	00000	Error message	The communication is abnormal
		Cause	Communication with the vision sensor was disconnected.
		Countermeasure	Check the communication cable.
L8621	00000	Error message	Vision program name is abnormal
		Cause	The program name has exceeded 15 characters.
		Countermeasure	Specify the program name within 15 characters.
L8632	00000	Error message	The vision is a time-out
		Cause	There is no response from the vision sensor.
		Countermeasure	Check the timeout time.

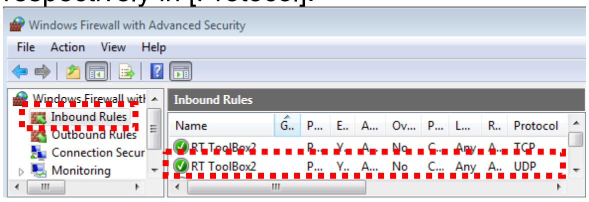
10.3. Q&A

<table>
<tr><th>No.</th><th>Symptom</th><th>Cause</th><th>Measure</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">The control unit power is ON, but the control unit setting/addition screen does not appear.</td><td>The control unit cannot be used.</td><td>It takes approximately 50 seconds from the time the power is turned ON until the unit can be used. Please wait.</td></tr>
<tr><td>The LAN cable may be disconnected or may be damaged.</td><td>Check the LAN cable.</td></tr>
<tr><td>Communication has been blocked by the firewall.</td><td>[Windows XP]
Select [Control Panel] - [Windows Firewall] - [Exceptions] tab, click the [Add Program] button, and specify "C:\Program Files\MELSOFT\RT ToolBox2\MELFA_RT.exe" (if using the default installation destination). Furthermore, ensure that the RT ToolBox2 item check box in the list at the [Exceptions] tab is selected, and click the [OK] button.


[Windows 7]
Select [Control Panel] - [System and Security] - [Allow an app through Windows Firewall], click the [Change settings] button, followed by the [Allow another app...] button, and specify "C:\Program Files\MELSOFT\RT ToolBox2\MELFA_RT.exe" (if using the default installation destination) to add it. Select the "Domain", "Home/Work (Private)", or "Public" check box based on the usage environment, and then click the [OK] button.</td></tr>
</table>

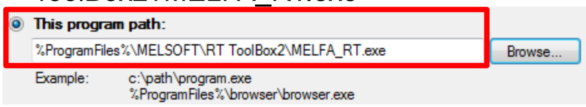


Select [Control Panel] - [System and Security] - [Windows Firewall] - [Advanced].
On the following screen, select [Inbound Rules], then confirm that there are two "RT ToolBox2" and "TCP" and "UDP" are selected respectively in [Protocol].



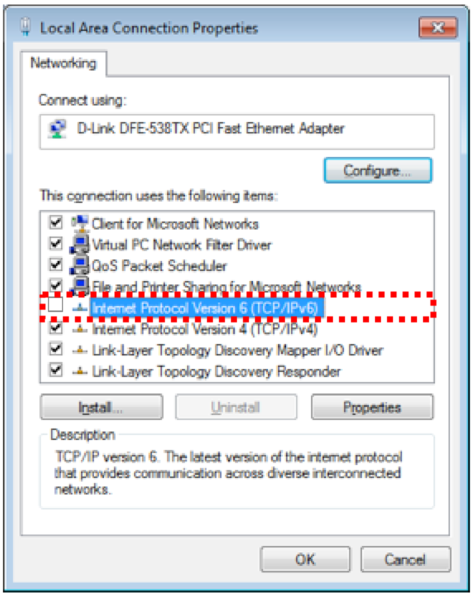
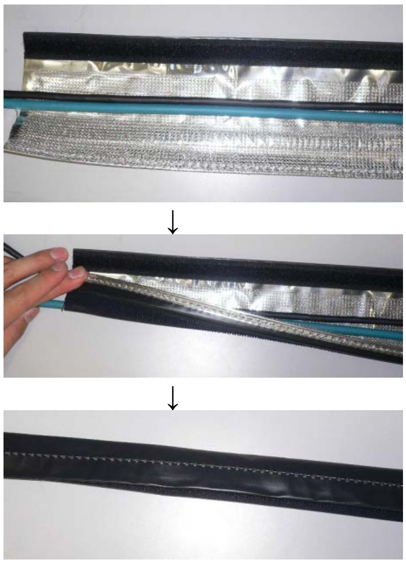
* When the port input for UDP is not admitted:
Select [New rule] from the above mentioned screen and start the new inbound rule wizard. Configure the settings as follows in each step of the wizard.
<Step: Rule types>
Select [Custom] and then click [Next].
<Step: Program>
Select [This program path], then configure the execution file for RT ToolBox2.

- For 32-bit OS:
  %ProgramFiles%¥MELSOFT¥RT ToolBox2¥MELFA_RT.exe
- For 64-bit OS:
  %ProgramFiles% (x86)¥MELSOFT¥RT ToolBox2¥MELFA_RT.exe



<Step: Protocol and port>
Select [UDP] under [Protocol types].
<Step: Scope>
Under the initial settings, click [Next].
<Step: Operation>
In the state in which [Allow the connection] is selected, click [Next].
<Step: Profile>
Confirm the settings in accordance with your network settings.
<Step: Name>
Input "RT ToolBox2" into [Name], then click [Complete].

		Communication has been blocked by the anti-virus software.	[If using anti-virus software] Refer to the manual for the relevant product and specify communication permission settings for "C:\Program Files\MELSOFT\RT ToolBox2\MELFA_RT.exe" (if using the default installation destination) in the firewall settings.
2	The control unit power is ON, but the MELFA-3D Vision setting screen does not appear even when double-clicking the control unit added to the workspace.	Same as No.1	Same as No.1
3	V3Open was executed, but an L3142 error occurred, and it is not possible to connect to the control unit.	The subnet mask setting for the IP address set at the control unit setting/addition screen differs from the IP address set in the robot Ethernet settings.	Ensure that the □part in the IP address "□□□-□□□-□□□-△△△" is same for both the control unit and robot.
		The port No. set at the control unit setting/addition screen differs from that set in the robot Ethernet settings.	Enter the same port No. in the robot Ethernet settings as that set for the control unit.
		The COM No. specified with V3Open is incorrect.	Check the specified COM No.
		The LAN cable is damaged or not connected.	Check the LAN cable.
		Communication has been blocked by the firewall.	Same as No.1
4	V3Open was executed, but an L8610 error occurred, and it is not possible to connect to the control unit.	The LAN cable is damaged or not connected.	Check the LAN cable.
		The control unit has becomes illegal.	Restart the control unit. If the problem persists, contact the manufacturer.
5	V3Open was executed, but an L8632 error occurred, and it is not possible to connect to the control unit.	There is no response from the control unit.	Ensure that the port No. at the control unit "Robot communication settings" screen (see Fig. 7-28) is set for any of the port Nos. at the robot controller "Ethernet settings" screen (see Fig. 7-3).

6	Fail to update the software	Connection delay or failure has occurred according to IPv6 setting.	Open the network setting window on your Host computer, and release the check on the item IPv6. 
7	The response from the camera head is not stable.	There is a suspicious about the influence of noise in the environment.	Please take measures to the noise. Ex. Set the shield cover around 2 cables between the control unit and the camera head. (Refer to 6.4 Wiring of equipment) 〔How to set the shield cover〕  When the situation does not refine, please contact us.
8	Pattern projection is not actioned after switching on the vision sensor. (Or no response to the command)	There are suspicious on the disconnection or breaking of the LAN cable and power cable.	Please check the cable connection and cables.
9	When the Ready signal output is set, error 4320 occurs with the robot controller.	This is because cycles are fixed in the IO processing mode.	Change the IO processing mode to the high-speed mode (change the parameter "SYNIO" of the robot controller to 1 or 2).

11. APPENDIX

11.1. Camera Focus Adjustment Sheet

Cut out and use the following pattern when performing camera focus adjustment.

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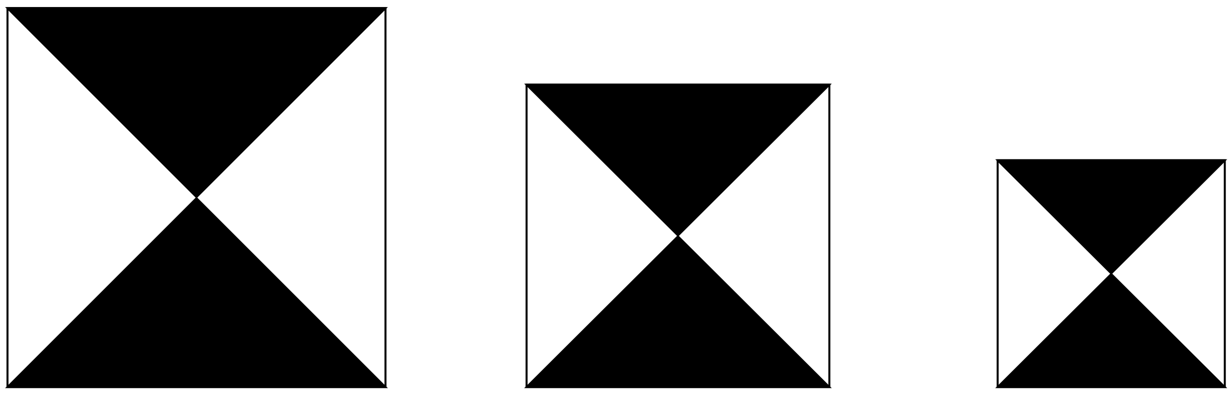
11.2. Robot Calibration Program "JRCA.prg"

```
'[Arrangement declaration]
Dim PG_CLB(8)                    'Calibration posture
'[Connection to MELFA-3D Vision]
If M_Open(1) <> 2 Then           'If vision sensor No. 1 is not capable of measurement
  V3Open "COM2:" As #1           'Connect to vision sensor connected to COM2: and set number to 1.
EndIf
Wait M_Open(1) = 2               'Connect to vision sensor No. 1 and wait until measurement is
possible.
'[Change to 10% when override is greater than 10%]
If M_Ovrd > 10 Then
  Ovrd 10
EndIf
'[Recognition of robot calibration plate]
Mov PG_CLB(5)                    'Move to shelter point.
For M1=1 To 8
  MOK=0
  Mov PG_CLB(5)
  Mov PG_CLB(M1)                 'Move to calibration posture.
  Dly 3                          'Wait until static.
  While MOK=0                    'Repeat until successful.
    V3Calib #1,M1,1              'Perform robot calibration plate recognition.
    *LP1:If M_V3Rslt(1) = -1 GoTo *LP1     'Wait until complete.
    If M_V3Rslt(1) = 0 Then MOK=1          'Proceed if successful.
  WEnd
Next M1
'[Robot calibration calculation]
V3Calc #1,1                      'Perform calibration calculation.
*LP9:If M_V3Rslt(1) = -1 GoTo *LP9         'Wait until complete.
If M_V3Rslt(1) <> 0 Then Error 9000+M_V3Rslt(1)
'
V3Close #1                       'Close connection.
Mov PG_CLB(5)
Mov PG_CLB(1)                    'Move to 1st point.
Hlt
End
```

11.3. Calibration Sheet (For Non-contact type calibration)

When performing the fixed camera calibration, use the sheet as a jig affixed to the hand.

Depending on the usage environment (camera field of view size), **enlarge and reduce.**
If using with sizes other than this, **a calibration sheet may be prepared by the customer.**

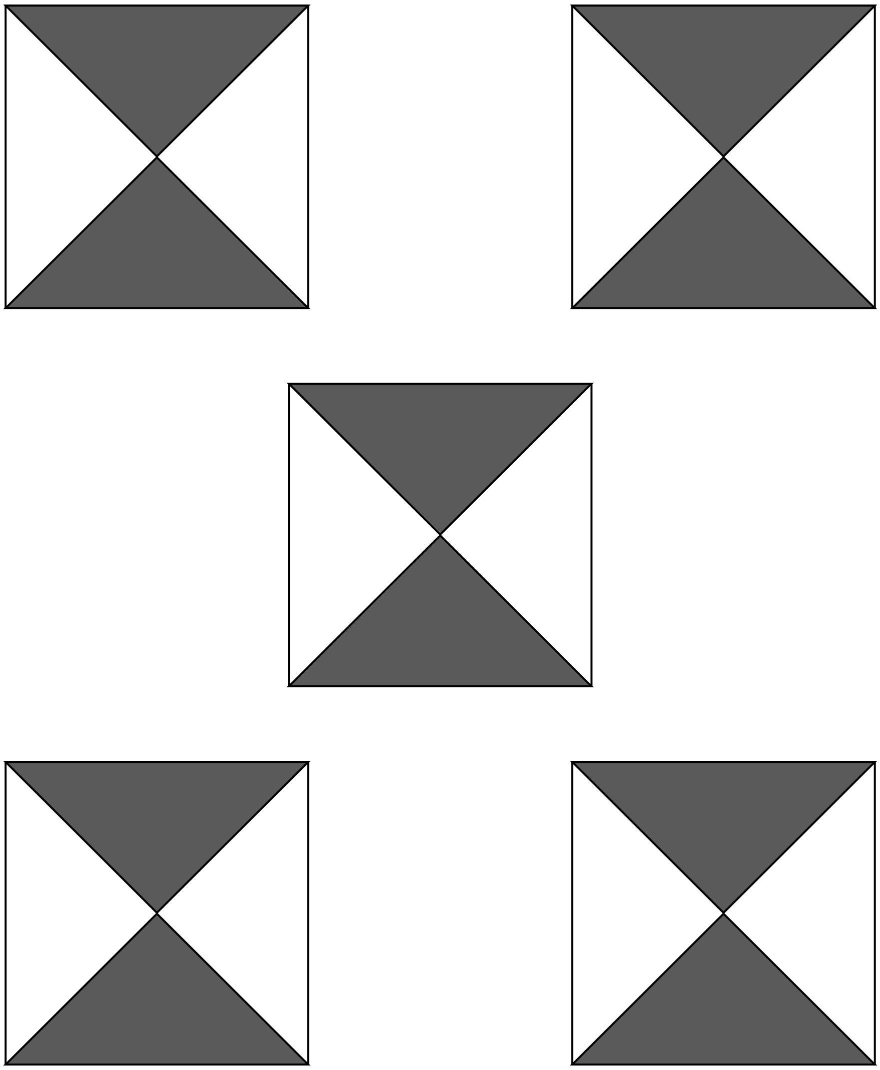


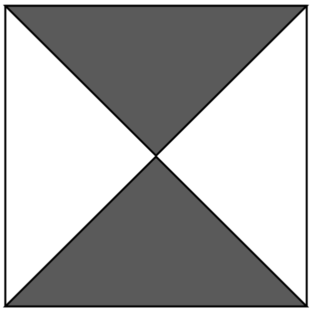
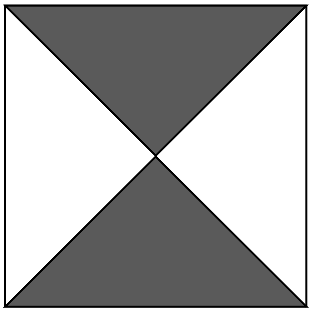
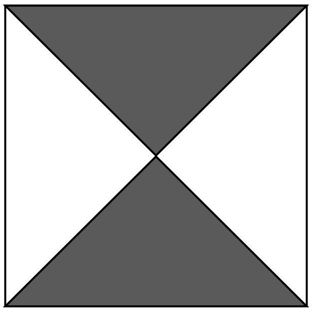
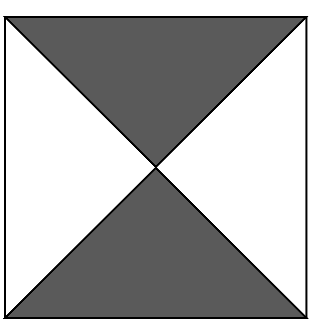
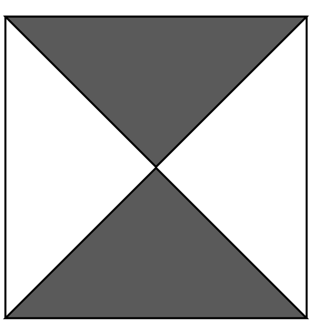
Depending on the usage environment (camera field of view size), **enlarge and reduce.**
If using with sizes other than this, **a calibration sheet may be prepared by the customer.**

11.4. Calibration Sheet (For Contact type calibration)

When performing the contact type calibration method, use the sheet as target marks.

Depending on the usage environment (camera field of view size), **enlarge and reduce.**
If the configuration varies often, **placing separate marks may be useful**.



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