MITSUBISHI ELECTRIC

Mitsubishi Electric Industrial Robot

CR800 series controller
CR750/CR751 series controller

MELFA-3D Vision 2.0
Instruction Manual

4F-3DVS2-PKG3

MELFA

BFP-A3626-D

⚠ Safety Precautions

Always read the following precautions and the separate "Safety Manual" before starting use of the robot to learn the required measures to be taken.

⚠ Caution

All teaching work must be carried out by an operator who has received special training. (This also applies to maintenance work with the power source turned ON.)
Enforcement of safety training

⚠ Caution

For teaching work, prepare a work plan related to the methods and procedures of operating the robot, and to the measures to be taken when an error occurs or when restarting. Carry out work following this plan. (This also applies to maintenance work with the power source turned ON.)
Preparation of work plan

⚠ Warning

Prepare a device that allows operation to be stopped immediately during teaching work. (This also applies to maintenance work with the power source turned ON.)
Setting of emergency stop switch

⚠ Caution

During teaching work, place a sign indicating that teaching work is in progress on the start switch, etc. (This also applies to maintenance work with the power source turned ON.)
Indication of teaching work in progress

⚠ Danger

Provide a fence or enclosure during operation to prevent contact of the operator and robot.
Installation of safety fence

⚠ Caution

Establish a set signaling method to the related operators for starting work, and follow this method.
Signaling of operation start

⚠ Caution

As a principle turn the power OFF during maintenance work. Place a sign indicating that maintenance work is in progress on the start switch, etc. Indication of maintenance work in progress

⚠ Caution

Before starting work, inspect the robot, emergency stop switch and other related devices, etc., and confirm that there are no errors.
Inspection before starting work

The points of the precautions given in the separate "Safety Manual" are given below. Refer to the actual "Safety Manual" for details.

⚠ Danger	When automatic operation of the robot is performed using multiple control devices (GOT, programmable controller, push-button switch), the interlocking of operation rights of the devices, etc. must be designed by the customer.
⚠ Caution	Use the robot within the environment given in the specifications. Failure to do so could lead to a drop or reliability or faults. (Temperature, humidity, atmosphere, noise environment, etc.)
⚠ Caution	Transport the robot with the designated transportation posture. Transporting the robot in a non-designated posture could lead to personal injuries or faults from dropping.
⚠ Caution	Always use the robot installed on a secure table. Use in an instable posture could lead to positional deviation and vibration.
⚠ Caution	Wire the cable as far away from noise sources as possible. If placed near a noise source, positional deviation or malfunction could occur.
⚠ Caution	Do not apply excessive force on the connector or excessively bend the cable. Failure to observe this could lead to contact defects or wire breakage.
⚠ Caution	Make sure that the workpiece weight, including the hand, does not exceed the rated load or tolerable torque. Exceeding these values could lead to alarms or faults.
⚠ Warning	Securely install the hand and tool, and securely grasp the workpiece. Failure to observe this could lead to personal injuries or damage if the object comes off or flies off during operation.
⚠ Warning	Securely ground the robot and controller. Failure to observe this could lead to malfunctioning by noise or to electric shock accidents.
⚠ Caution	Indicate the operation state during robot operation. Failure to indicate the state could lead to operators approaching the robot or to incorrect operation.
⚠ Warning	When carrying out teaching work in the robot's movement range, always secure the priority right for the robot control. Failure to observe this could lead to personal injuries or damage if the robot is started with external commands.
⚠ Caution	Keep the jog speed as low as possible, and always watch the robot. Failure to do so could lead to interference with the workpiece or peripheral devices.
⚠ Caution	After editing the program, always confirm the operation with step operation before starting automatic operation. Failure to do so could lead to interference with peripheral devices because of programming mistakes, etc.
⚠ Caution	Make sure that if the safety fence entrance door is opened during automatic operation, the door is locked or that the robot will automatically stop. Failure to do so could lead to personal injuries.
⚠ Caution	Never carry out modifications based on personal judgments, or use non- designated maintenance parts. Failure to observe this could lead to faults or failures.

⚠ Warning

When the robot arm has to be moved by hand from an external area, do not place hands or fingers in the openings. Failure to observe this could lead to hands or fingers catching depending on the posture.

⚠ Caution

Do not stop the robot or apply emergency stop by turning the robot controller's main power OFF. If the robot controller main power is turned OFF during automatic operation, the robot accuracy could be adversely affected. Moreover, it may interfere with the peripheral device by drop or move by inertia of the arm.

⚠ Caution

Do not turn off the main power to the robot controller while rewriting the internal information of the robot controller such as the program or parameters. If the main power to the robot controller is turned off while in automatic operation or rewriting the program or parameters, the internal information of the robot controller may be damaged.

⚠ Danger

Do not connect the Handy GOT when using the GOT direct connection function of this product. Failure to observe this may result in property damage or bodily injury because the Handy GOT can automatically operate the robot regardless of whether the operation rights are enabled or not.

⚠ Danger

Do not connect the Handy GOT to a programmable controller when using an iQ Platform compatible product with the CR800-R/CR800-Q controller. Failure to observe this may result in property damage or bodily injury because the Handy GOT can automatically operate the robot regardless of whether the operation rights are enabled or not.

⚠ Danger

Do not remove the SSCNET III cable while power is supplied to the multiple CPU system or the servo amplifier. Do not look directly at light emitted from the tip of SSCNET III connectors or SSCNET III cables of the Motion CPU or the servo amplifier. Eye discomfort may be felt if exposed to the light. (Reference: SSCNET III employs a Class 1 or equivalent light source as specified in JIS C 6802 and IEC60825-1 (domestic standards in Japan).)

⚠ Danger

Do not remove the SSCNET III cable while power is supplied to the controller. 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. (Reference: SSCNET III employs a Class 1 or equivalent light source as specified in JIS C 6802 and IEC60825-1 (domestic standards in Japan).)

⚠ Danger

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, and leading to malfunction.

⚠ Caution

Make sure there are no mistakes in the wiring. Connecting differently to the way specified in the manual can result in errors, such as the emergency stop not being released. In order to prevent errors occurring, please be sure to check that all functions (such as the teaching box emergency stop, customer emer- gency stop, and door switch) are working properly after the wiring setup is com- pleted.

⚠ Caution

Use the network equipments (personal computer, USB hub, LAN hub, etc) confirmed by manufacturer. The thing unsuitable for the FA environment (related with conformity, temperature or noise) exists in the equipments connected to USB. When using network equipment, measures against the noise, such as measures against EMI and the addition of the ferrite core, may be necessary. Please fully confirm the operation by customer. Guarantee and maintenance of the equipment on the market (usual office automation equipment) cannot be performed.

⚠ Caution

To maintain the security (confidentiality, integrity, and availability) of the robot and the system against unauthorized access, DoS[*1] attacks, computer viruses, and other cyberattacks from unreliable networks and devices via network, take appropriate measures such as firewalls, virtual private networks (VPNs), and antivirus solutions. Mitsubishi Electric shall have no responsibility or liability for any problems involving robot trouble and system trouble by unauthorized access, DoS attacks, computer viruses, and other cyberattacks.
*1 DoS: A denial-of-service (DoS) attack disrupts services by overloading systems or exploiting vulnerabilities, resulting in a denial-of-service (DoS) state.

⚠ 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
2018-09-28	BFP-A3626	• First edition
2019-01-31	BFP-A3626-A	• Added "Note 10". (Table 3-1)
2020-01-24	BFP-A3626-B	• Modified the figures. (Table 3-2, Fig. 3-13) • Corrected the remarks of No. 6 "Additional camera head". (Table 4-1) • Corrected the name. (Fig. 7-166)
2020-04-20	BFP-A3626-C	• Added a shield cover to product configuration. • Added further explanation when selecting workpiece models. • Added information on how to check the software version of MELFA-3D Vision.
2023-04-17	BFP-A3626-D	• Amended the precautions regarding the prevention of unauthorized access. • Corrected other mistakes and changed some sections.

■ Introduction

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

When adjusting the model-less recognition of MELFA-3D Vision, the MELFA Smart Plus function extended card automates the adjustment work of the recognition parameter, which requires technical knowledge, using the Mitsubishi Electric AI technology and simulation technology.

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 ToolBox3.
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	Robot Program 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	It consists of a 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 3.4 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
MELFA Smart Plus card pack MELFA Smart Plus card	A function extended card for the CR800 robot controller. The MELFA Smart Plus card pack can use all of the MELFA Smart Plus functions. The MELFA Smart Plus card can use one of the MELFA Smart Plus functions. In MELFA-3D Vision, MELFA-3D Vision extended functions such as the automatic adjustment of the recognition settings can be used. For details, refer to "MELFA Smart Plus User's Manual".

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.

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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 edge computer and 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 robots. It employs a camera head capable of acquiring distance information to measure and recognize parts loaded in bulk.
MELFA-3D Vision enables the hand attached to the robot to grip parts loaded in bulk. 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.

3.1.1. 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.

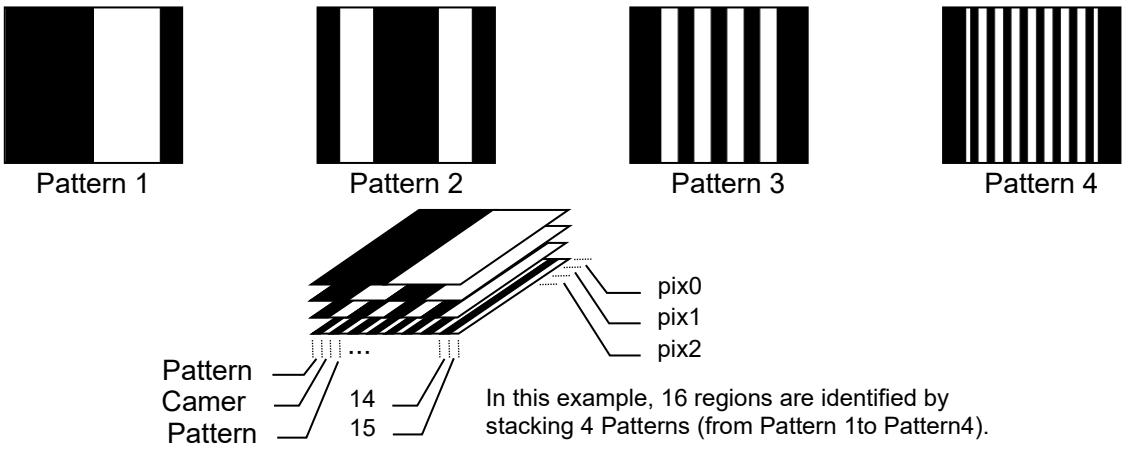


Fig. 3-2 Pattern irradiation example

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.

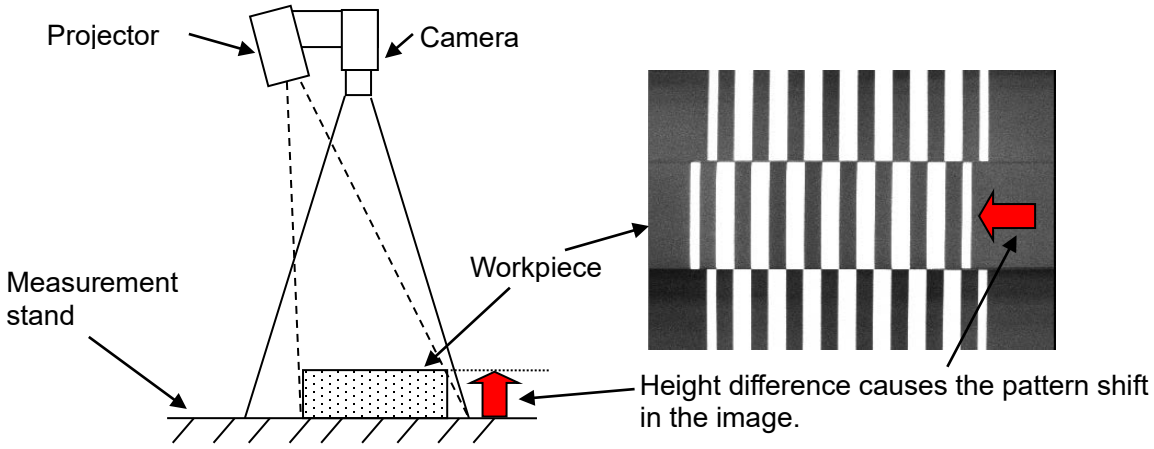


Fig. 3-3 Relationship between projector and camera

3.1.2. Model-less recognition

A recognition method that facilitates grasping of workpieces by registering the shapes of hand tabs and suction pads and searching for gaps into which tabs can be inserted and pad suction locations. No need to register workpiece shapes.

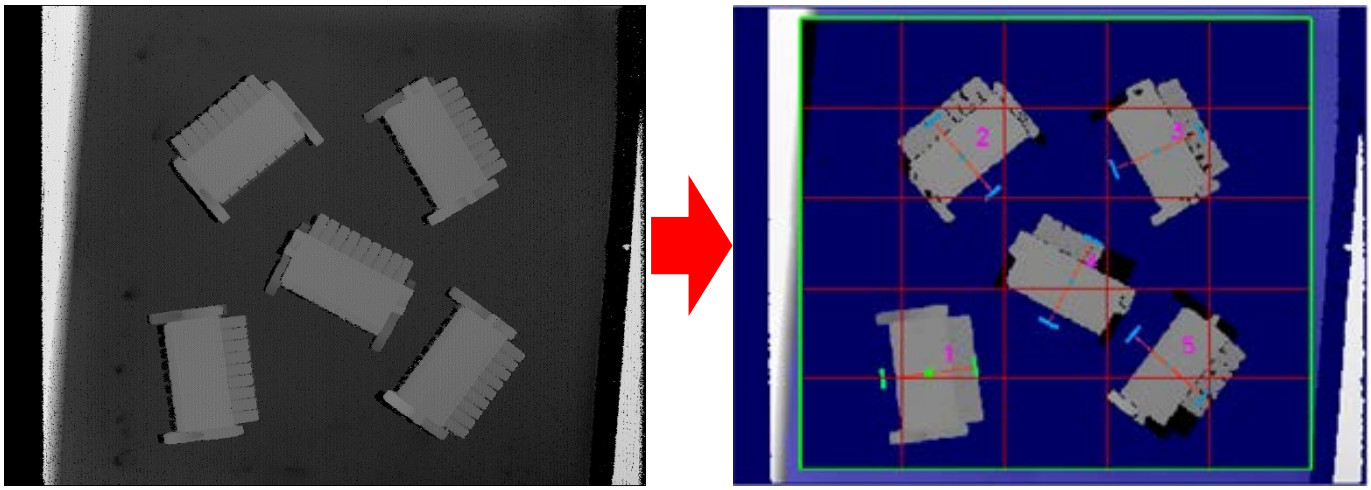


Fig. 3-4 Model-less recognition

Input the hand shape. Registering the workpiece model is not required regardless of the workpiece type.

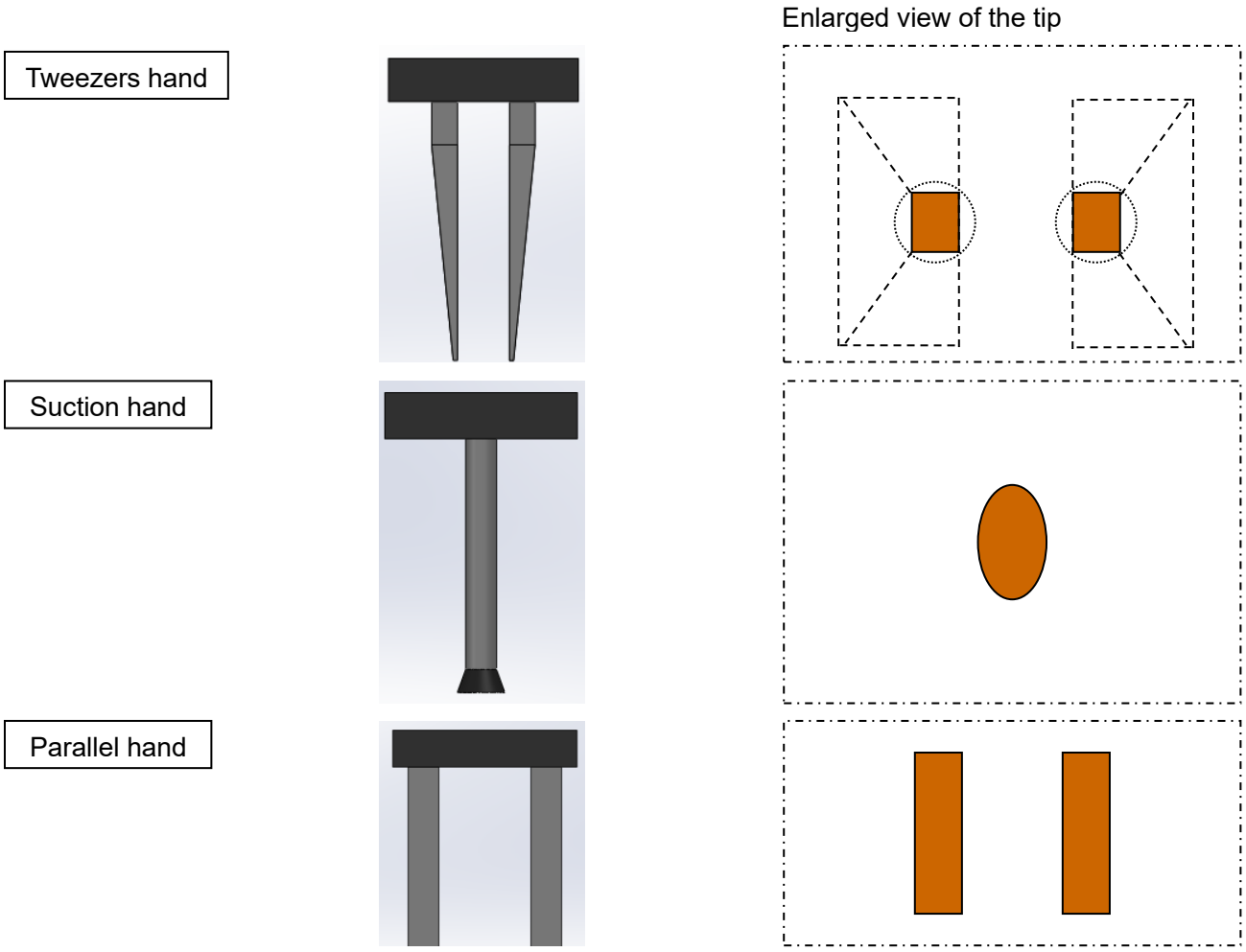


Fig. 3-5 Model-less recognition: Hand setting example

3.1.3. Model matching recognition

A recognition method that facilitates the gripping of workpieces by registering workpiece shapes in 3D-CAD models and searching for workpieces that match the 3D-CAD models. Therefore, the gripping location and posture of the workpieces can be identified.

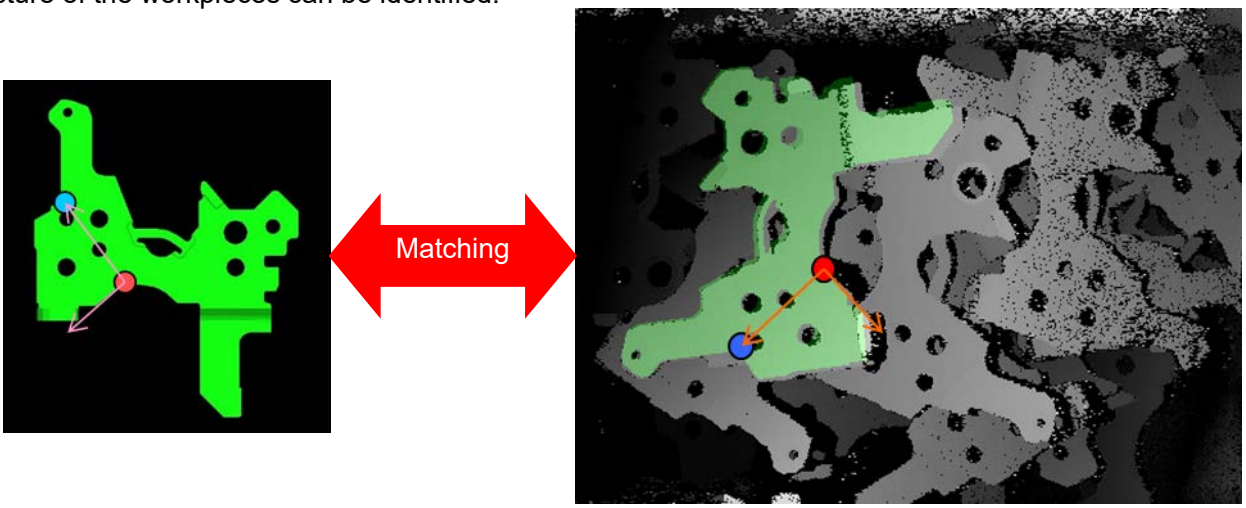


Fig. 3-6 Model matching recognition

3.1.4. Extended function

3.1.4.1. Recognition parameter automatic adjustment AI

When adjusting the model-less recognition of MELFA-3D Vision, the MELFA Smart Plus function extended card automates the adjustment work of the recognition parameter, which requires technical knowledge, using the Mitsubishi Electric AI technology and simulation technology.

The AI automatically adjusts the appropriate parameters in the virtual space. The parameters can be adjusted only with the 3D-CAD data Note 1 without preparing the actual device.

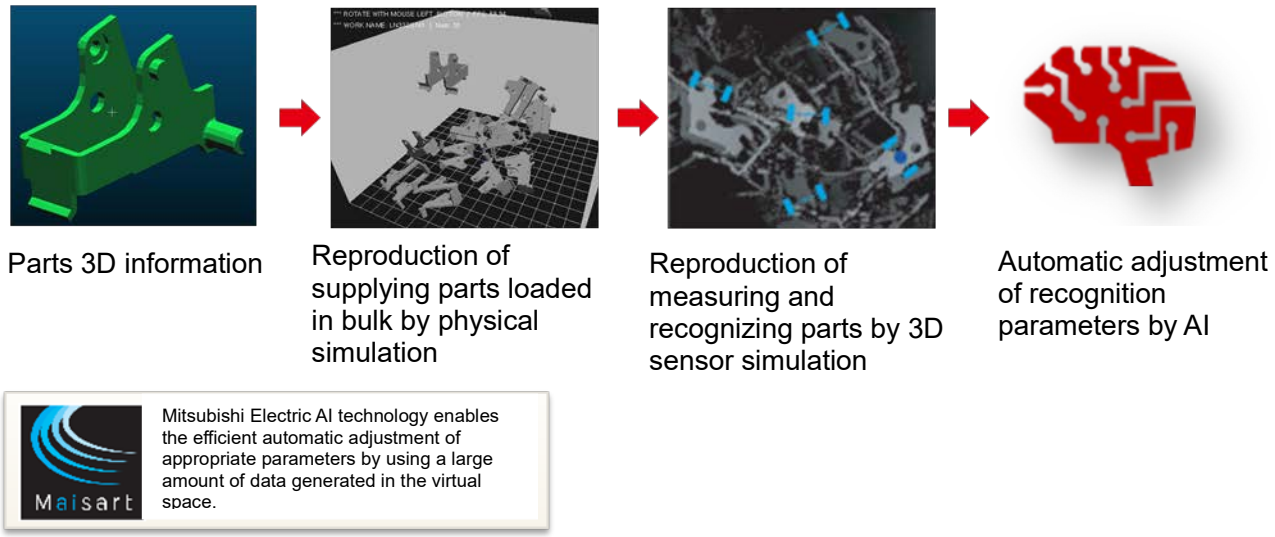


Fig. 3-7 Recognition parameter automatic adjustment AI

Note 1: The supported data format is the STL format, OBJ format, PLY format, and VRML format.

3.2. System Configuration Example

3.2.1. F series

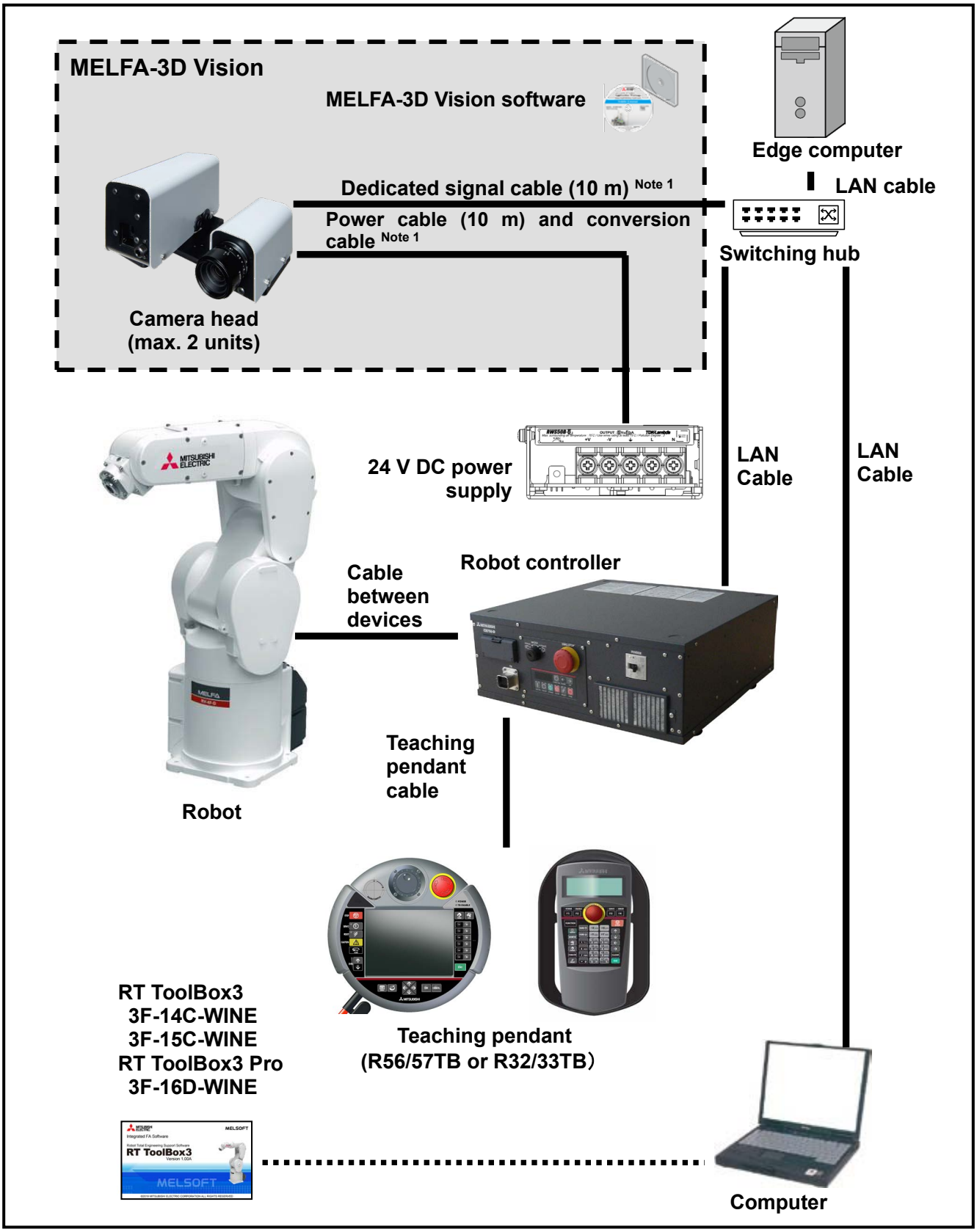


Fig. 3-8 MELFA-3D Vision system configuration drawing

Note1: When you attach a shield cover to reduce the electrical noise, please cover these cables from the end point near by the control unit. Since this area is not affected by bending due to robot operation from the edge computer side, the cables around the camera head can be exposed. For the attachment method, refer to "Fig. 6-6" and "Fig. 6-7".

3.2.2. FR series

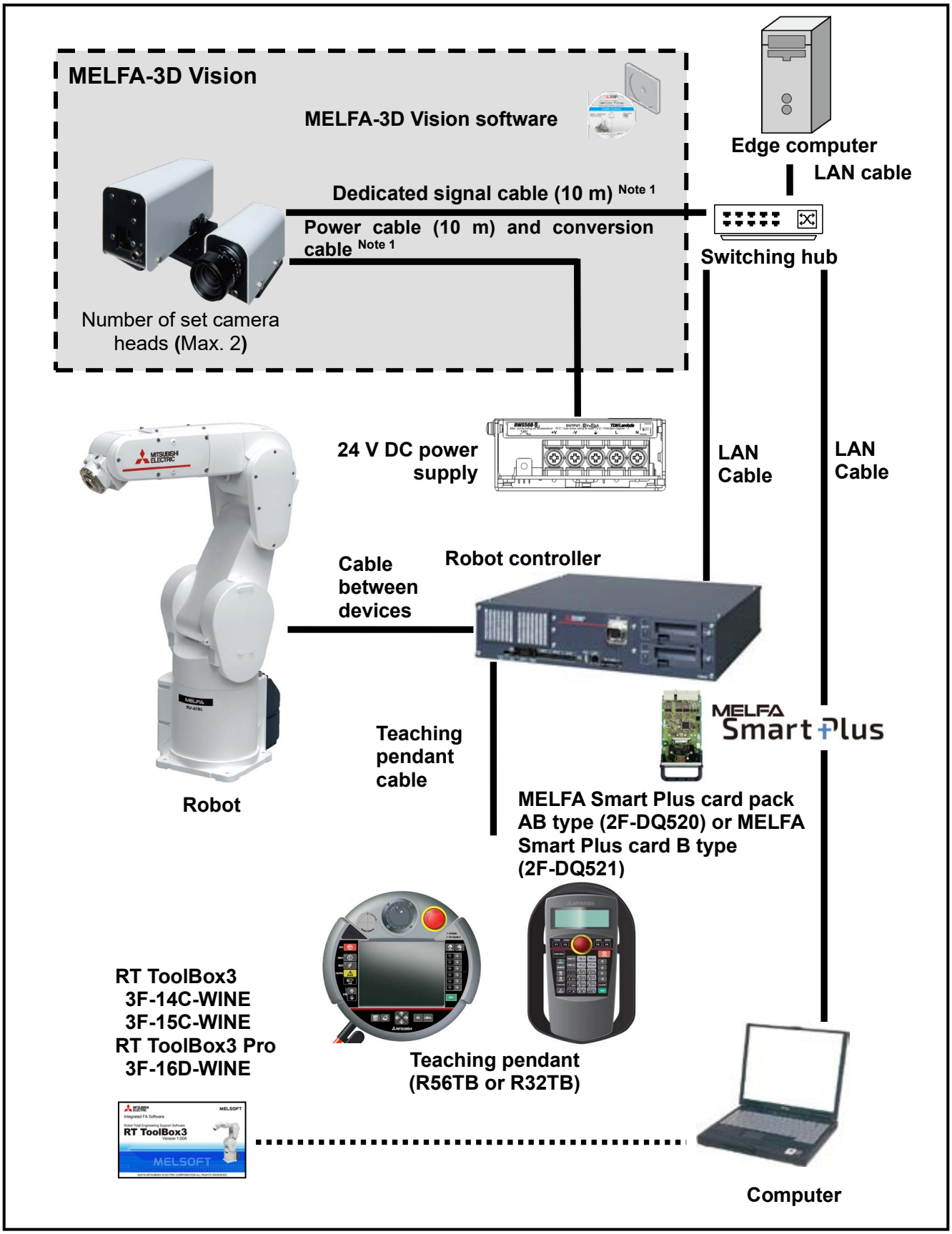


Fig. 3-9 MELFA-3D Vision system configuration drawing

Note1: When you attach a shield cover to reduce the electrical noise, please cover these cables from the end point near by the control unit. Since this area is not affected by bending due to robot operation from the edge computer side, the cables around the camera head can be exposed. For the attachment method, refer to "Fig. 6-6" and "Fig. 6-7".

3.3. MELFA-3D Vision Specifications

Table 3-1: MELFA-3D Vision specifications

Item			Function details
Applicable robot			F series or FR series Note 1
Robot programming language			MELFA-BASIC VI or MELFA-BASIC V
Robot controller	MELFA-3D Vision dedicated commands		Dedicated commands used to notify the edge computer of calibration and job execution commands, and to acquire recognition results.
Connection settings	Number of set camera heads		Max. 2
	Number of set robots		Max. 4
Calibration	Number of calibration data		Max. 15
Measurement Note 2			Send imaging commands to the camera head and calculate range images from captured pattern images.
	Measurement time		Approx. 1.3 s Note 3
Job	Number of registered job		Max. 250
	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 "0": Workpiece position in camera coordinates (XYZC) Note 4 Posture output "1 to 6": Workpiece position in robot coordinates (XYZABC) Note 4
		Recognition time	Approx. 0.5 s Note 3
	Model matching recognition Note 5		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
		Workpiece registration size/piece	Max. 8,500,000 bytes (8.1 MB)
		Workpiece 3D-CAD data format	STL format, OBJ format, PLY format, and VRML format
		Number of registered workpieces	Max. 250
		Number of registered workpiece parameters per workpiece	Max. 10
		Number of workpiece lists	Max. 250
		Number of recognition targets per workpiece list	Max. 100
		Recognition result output information	Workpiece position in robot coordinates (XYZABC)
		Recognition time	Approx. 1.0 s Note 3
	Recognition parameter automatic adjustment AI		When adjusting the model-less recognition, the adjustment work in Table 7-24, which requires technical knowledge, is automated using the Mitsubishi Electric AI technology and simulation technology. Note 6
		Workpiece registration size/piece	Max. 8,500,000 bytes (8.1 MB)
		Workpiece 3D-CAD data format	STL format, OBJ format, PLY format, and VRML format
		Adjustment time	Approx. 10 to 60 min Note 7

RT ToolBox3	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 edge computer

Note 1: The RV-F series or the RV-FR 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 indicates the standard time under the best conditions. The standard time may be exceeded depending on the conditions such as the edge computer performance, ambient environment, workpiece, processing parameters, and the number of registered jobs.

Note 4: For posture output, refer to "Posture output" in "Table 7-24 Recognition parameters".

Note 5: The RH-F series and the RH-FR series are not compatible with the model matching recognition.

Note 6: For the parameters that can be adjusted by the recognition parameter automatic adjustment AI, refer to "Table 7-24 Recognition parameter".

Note 7: The time will change depending on the conditions such as the edge computer performance, workpiece 3D-CAD data, and learning environment setting.

Note 8: 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.

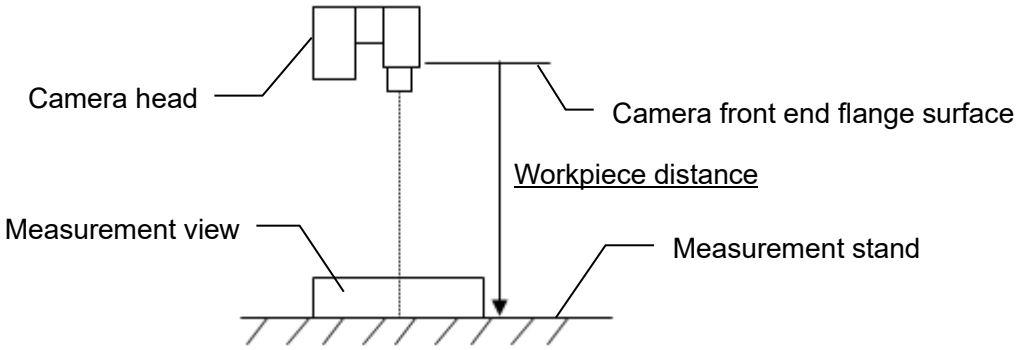
Note 9: For a picking operation of the model-less recognition, a 2D vision sensor may be required.

Note 10: Cannot be used with any safety function.

3.4. Camera Head Specifications

Table 3-2: Camera head specifications

Item			Unit	Specification	Remarks
Model name			-	2F-3DVS2-HEAD2	
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	Reference values
		Mounting base (large)		(1) 500 to 750 Note 4 (2) 750 to 1000 Note 5	Reference values
Measurement view Note 3 (horizontal x vertical x height)		Mounting base (small)	mm	100 x 80 to 165 x 130, about 70 mm	Reference values 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	Reference values
		Mounting base (large)		(1) 500 to 750 Note 4 (2) 750 to 1000 Note 5	Reference values
Measurement view Note 3 (horizontal x vertical x height)		Mounting base (small)	mm	140 x 90 to 240 x 160, about 70 mm	Reference values 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) *Attach the ferrite core to the power 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 "3.5.3 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. 3-13 Mounting base (large))
Note 5: If camera attached to mounting base (large) (ii) (see Fig. 3-13 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 "3.4.1 Protection specifications and working environment".)

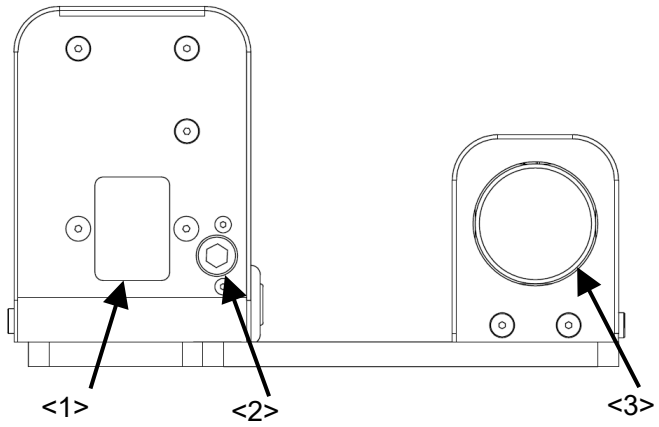
3.4.1. Protection specifications and working environment

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.

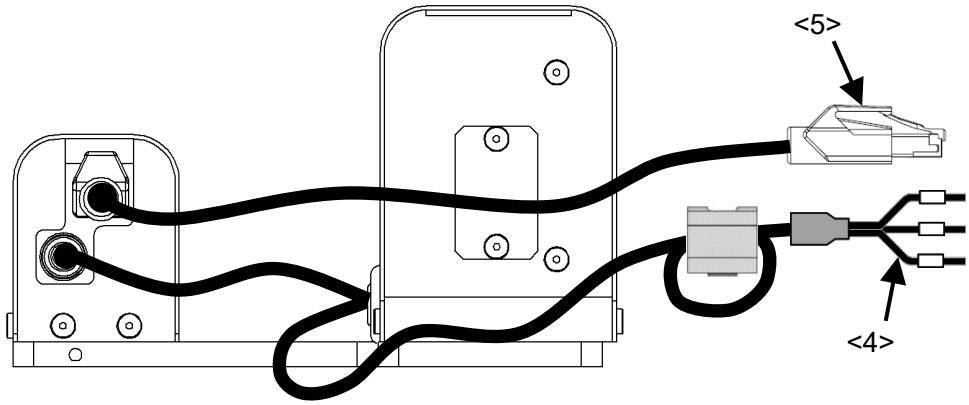
[Reference]
• IEC standard IP20
This refers to a protective structure that prevents an iron ball of diameter $12\ {}_{0}^{+0.05}$ mm, which is being pressed with a force of 3.1 kg ±10%, from going through the opening of the outer casing of the tested equipment.

3.4.2. Name of each part

<Camera head front view>



<Camera head rear view>



<Camera head underside view>

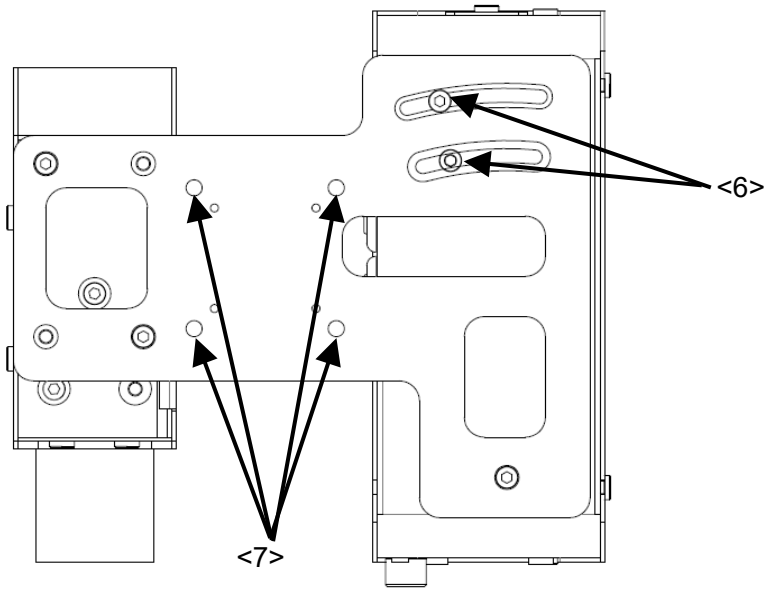


Fig. 3-10 Name of each camera head part

<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 supply cable: Connect to the prescribed terminal of the 24 V DC power supply.
<5> Dedicated communication connector: Connect to the LAN connector of the switching hub.
<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.

3.4.3. External dimensions

(1) Camera head

The camera head external drawing is shown below.

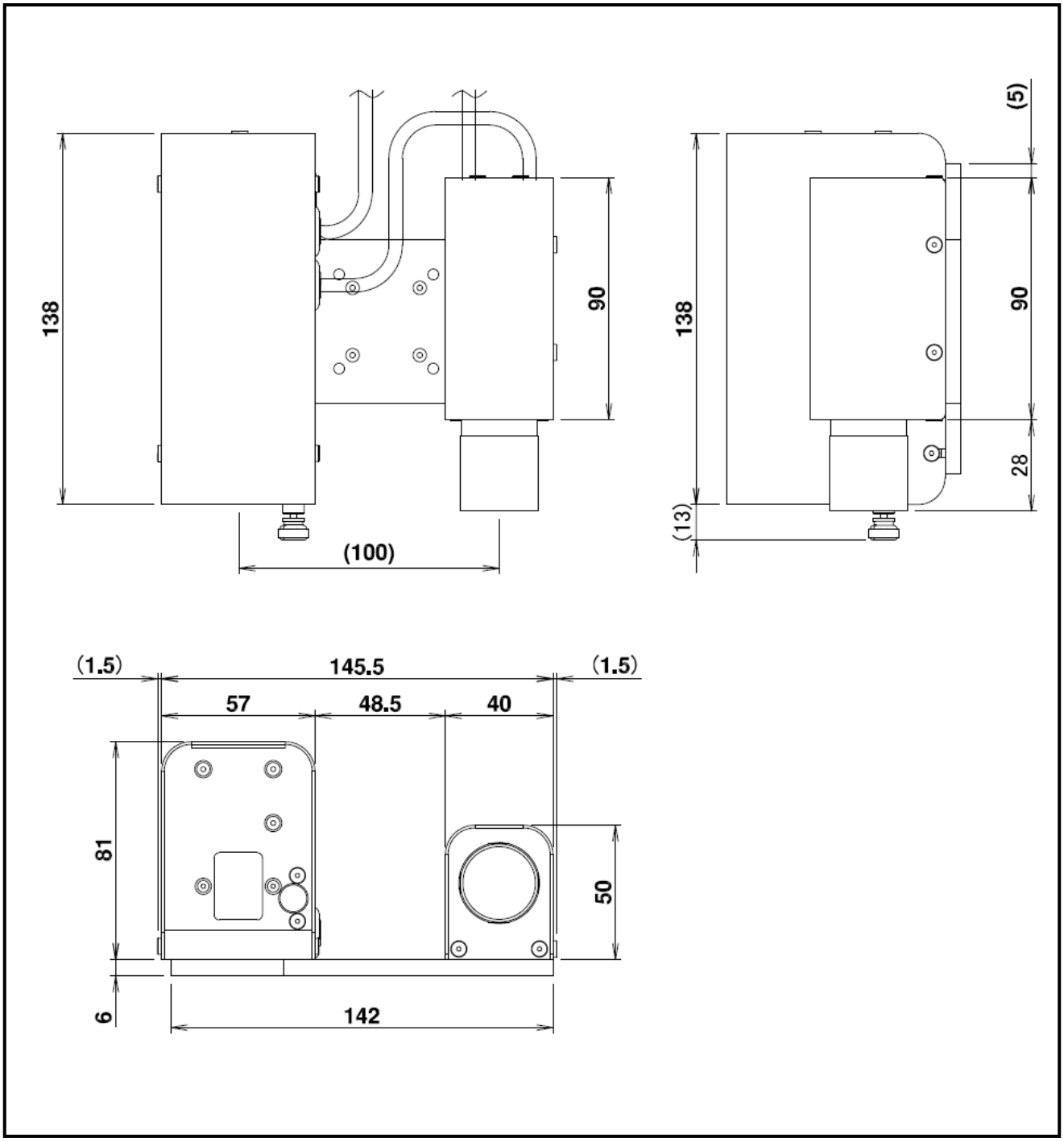


Fig. 3-11 Camera head external drawing (for mounting base (small))

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

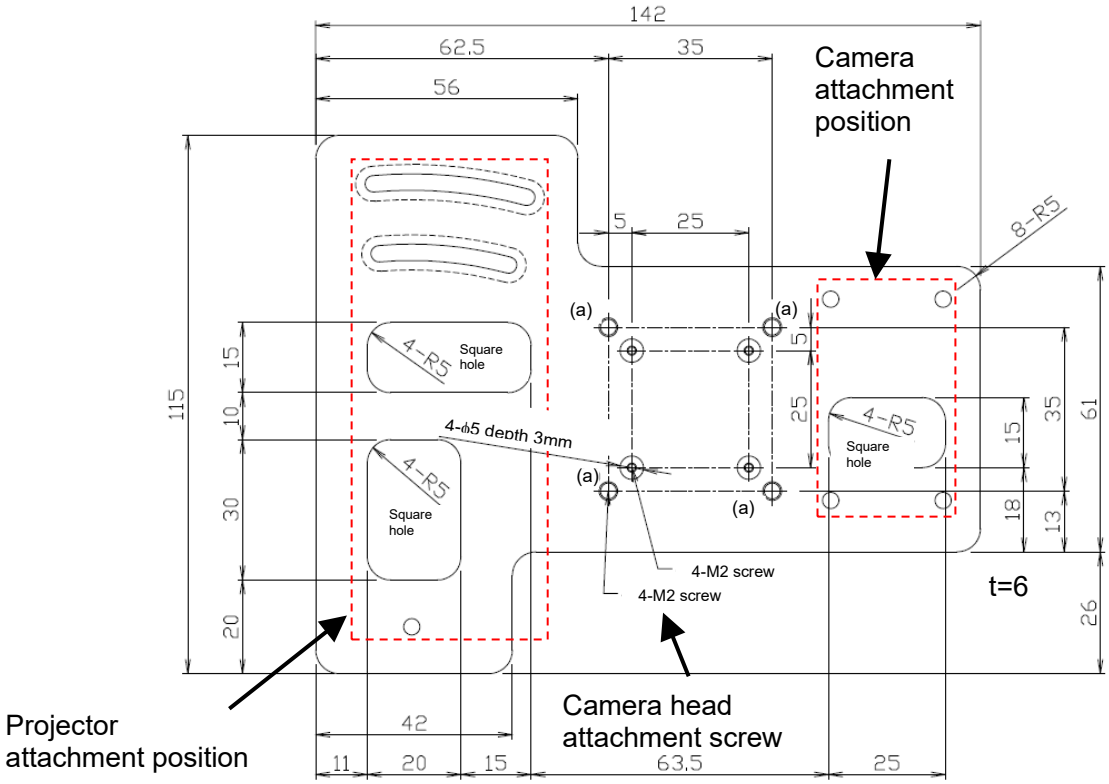


Fig. 3-12 Mounting base (small) (2F-3DVS2-BASE-S) Note 1

Note 1: Factory attached

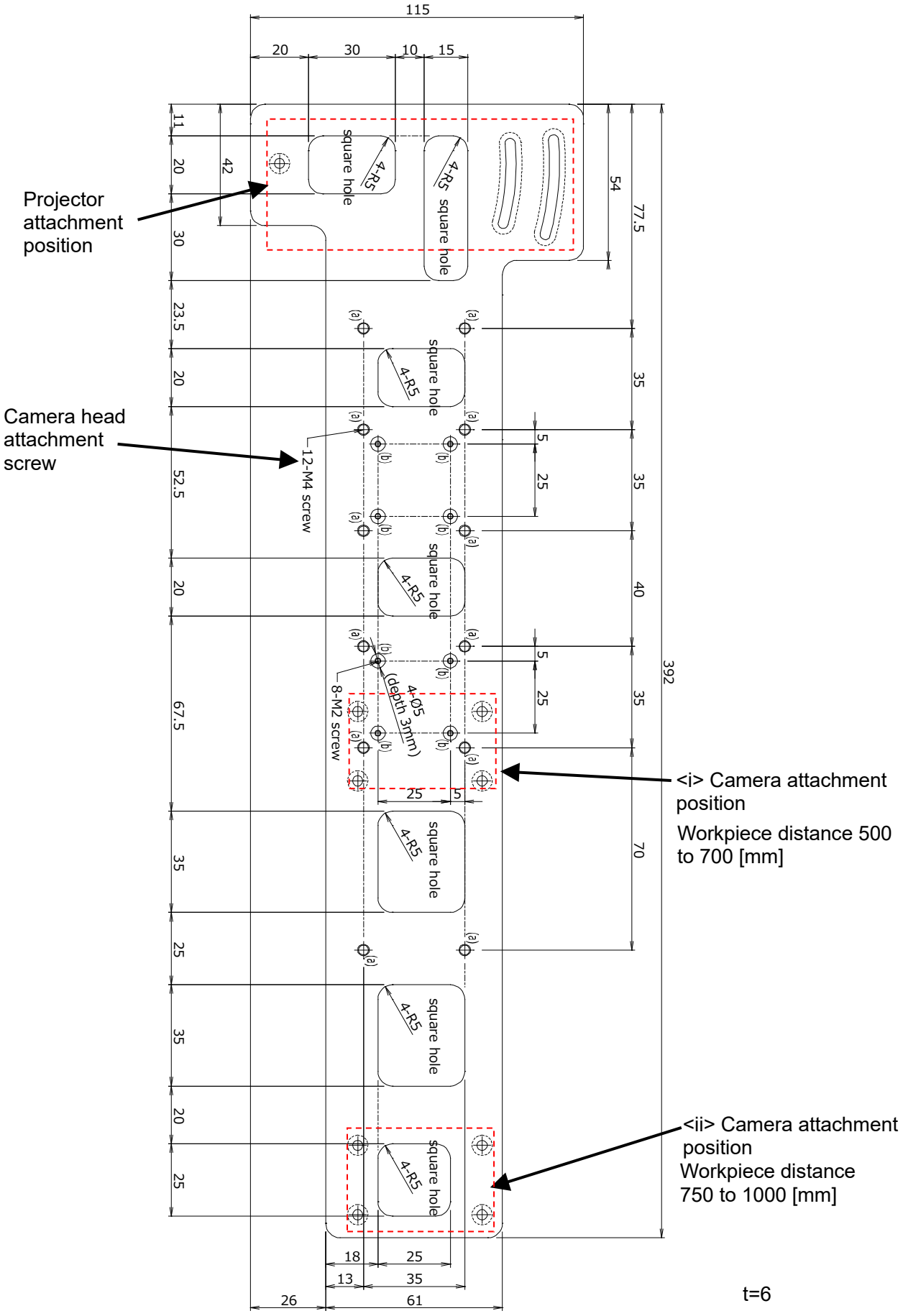


Fig. 3-13 Mounting base (large) (2F-3DVS2-BASE-L)

3.4.4. Camera coordinate system

The camera coordinate system is defined as follows.

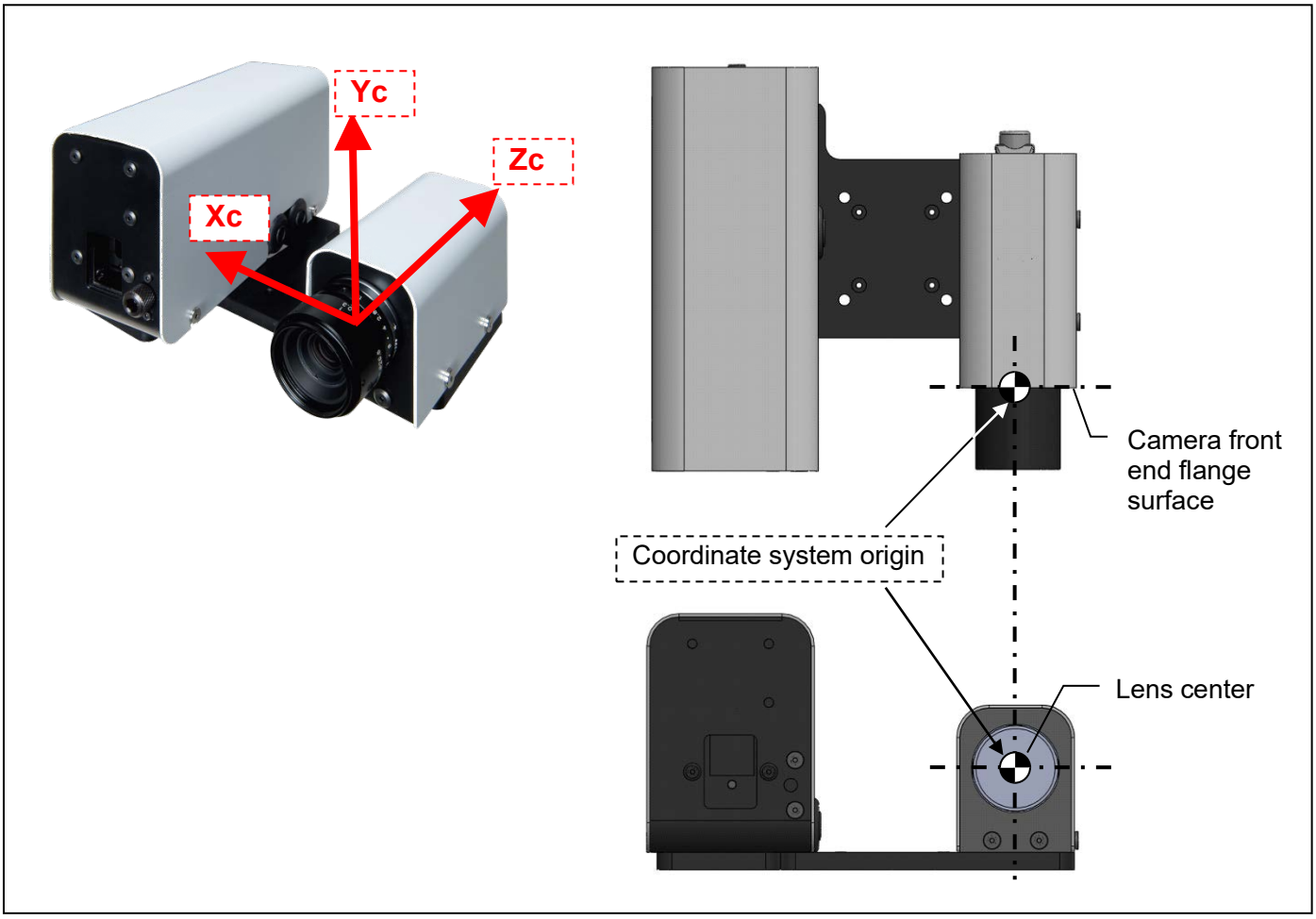


Fig. 3-14 Camera coordinate system

3.5. Restrictions

3.5.1. 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. 7-43.

3.5.2. Unmeasurable area of parts supply box

Based on the measurement principle described in 3.1.1, 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.

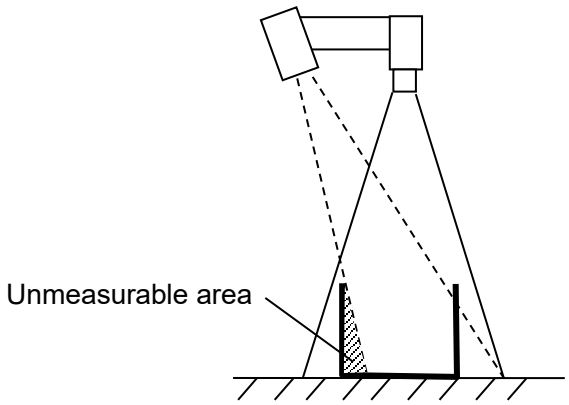


Fig. 3-15 Unmeasurable area of parts supply box

◇◆◇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.

3.5.3. 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.

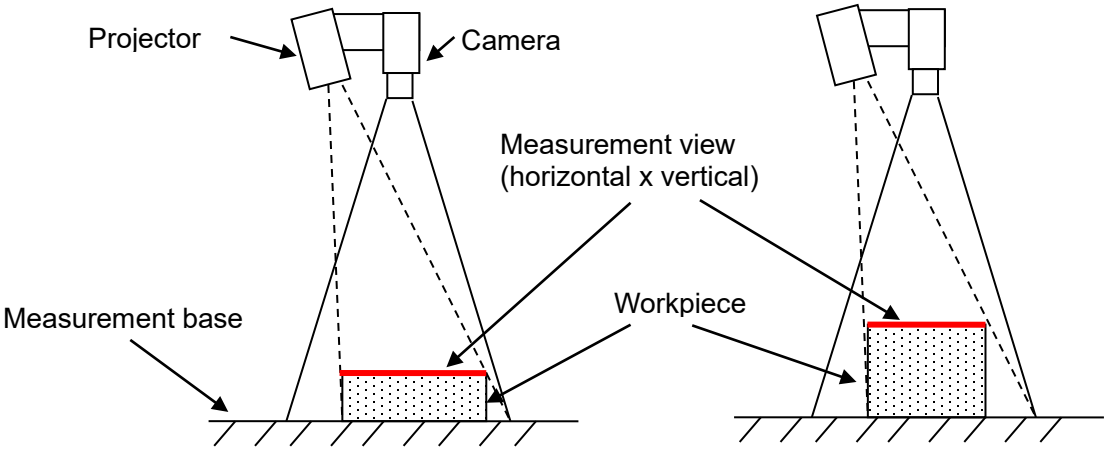


Fig. 3-16 Relationship between measurement view and workpiece distance

(1) When using a standard lens

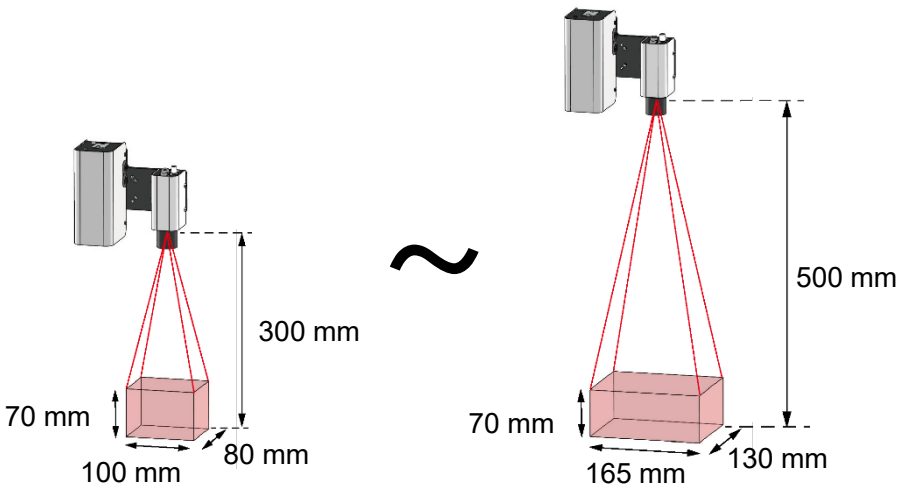


Fig. 3-17 Measurement view when attaching a camera to the mounting base (small) in Fig. 3-9 with a standard lens

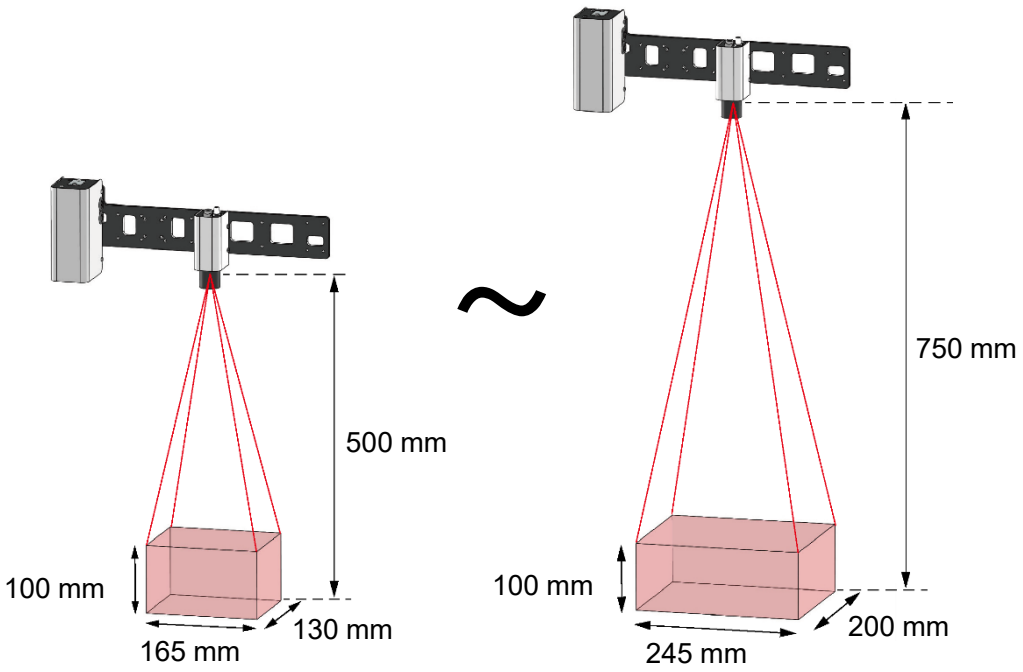


Fig. 3-18 Measurement view when attaching a camera to the mounting base (large) <i>
in Fig. 3-9 with a standard lens

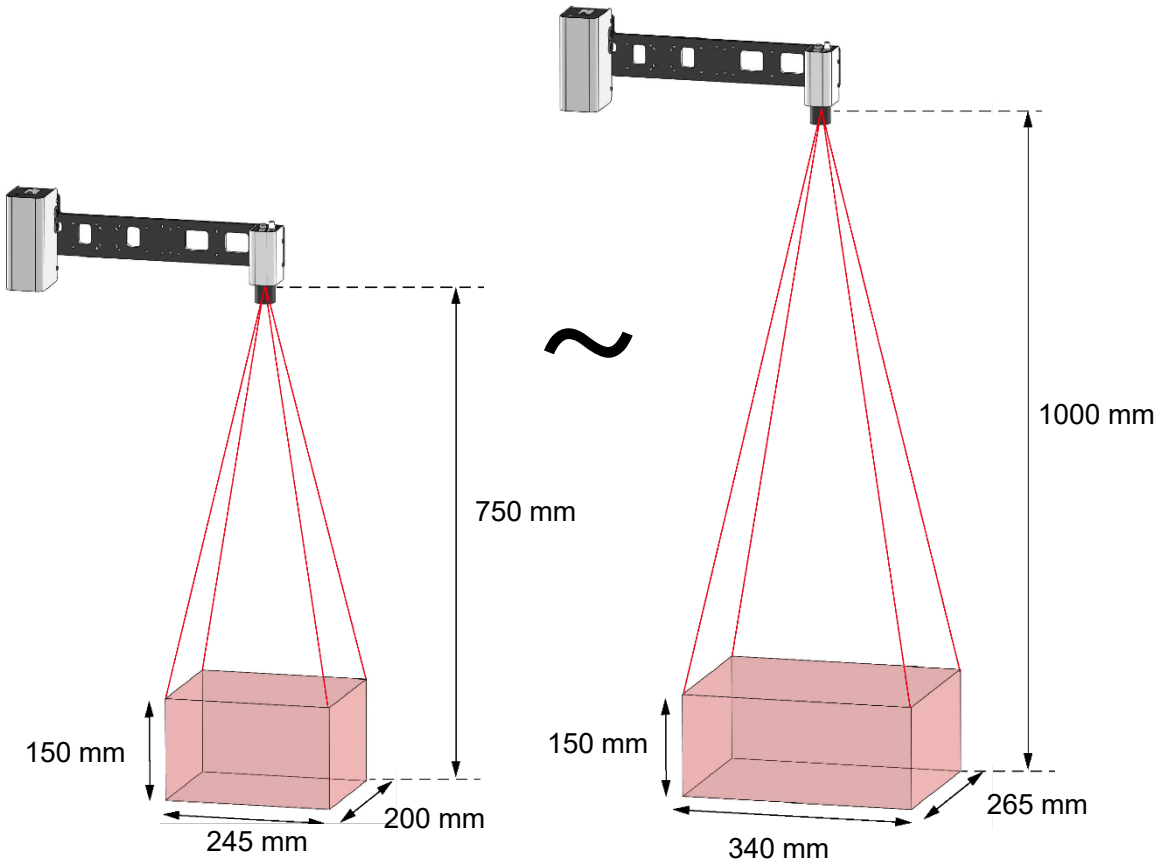


Fig. 3-19 easurement view when attaching a camera to the mounting base (large) <ii>
in Fig. 3-9 with a standard lens

(2) When using an optional lens for enlarged view

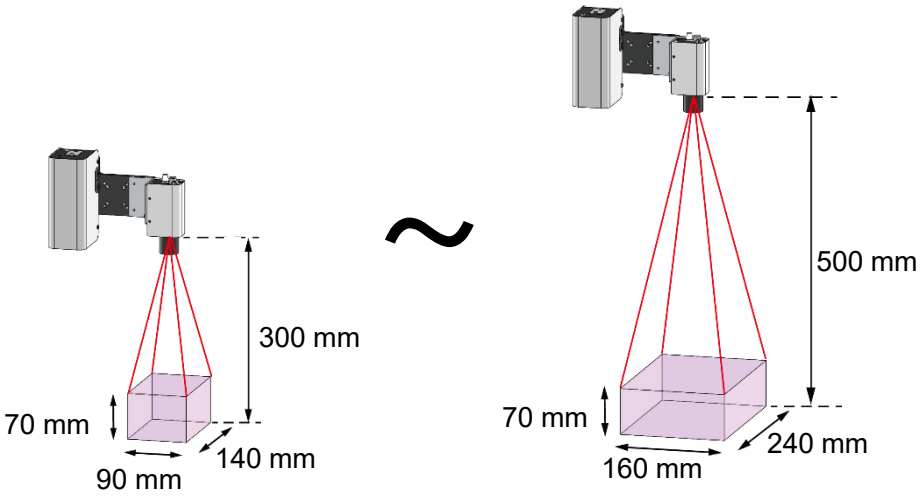


Fig. 3-20 Measurement view when attaching a camera to the mounting base (small) in Fig. 3-9 with an optional lens for enlarged view

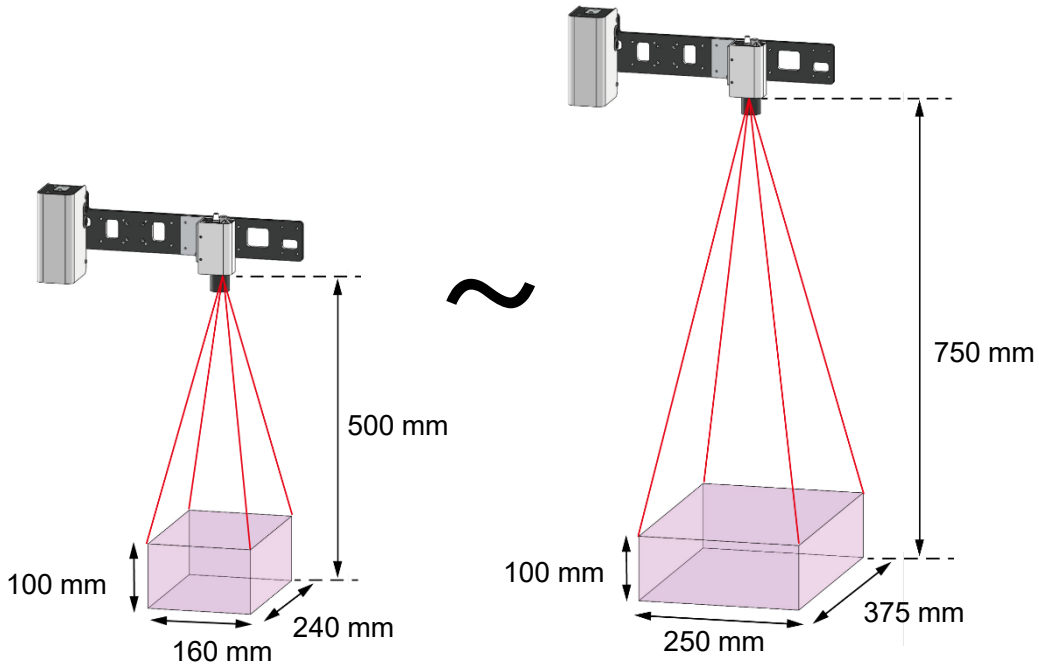


Fig. 3-21 Measurement view when attaching a camera to the mounting base (large) <i> in Fig. 3-9 with an optional lens for enlarged view

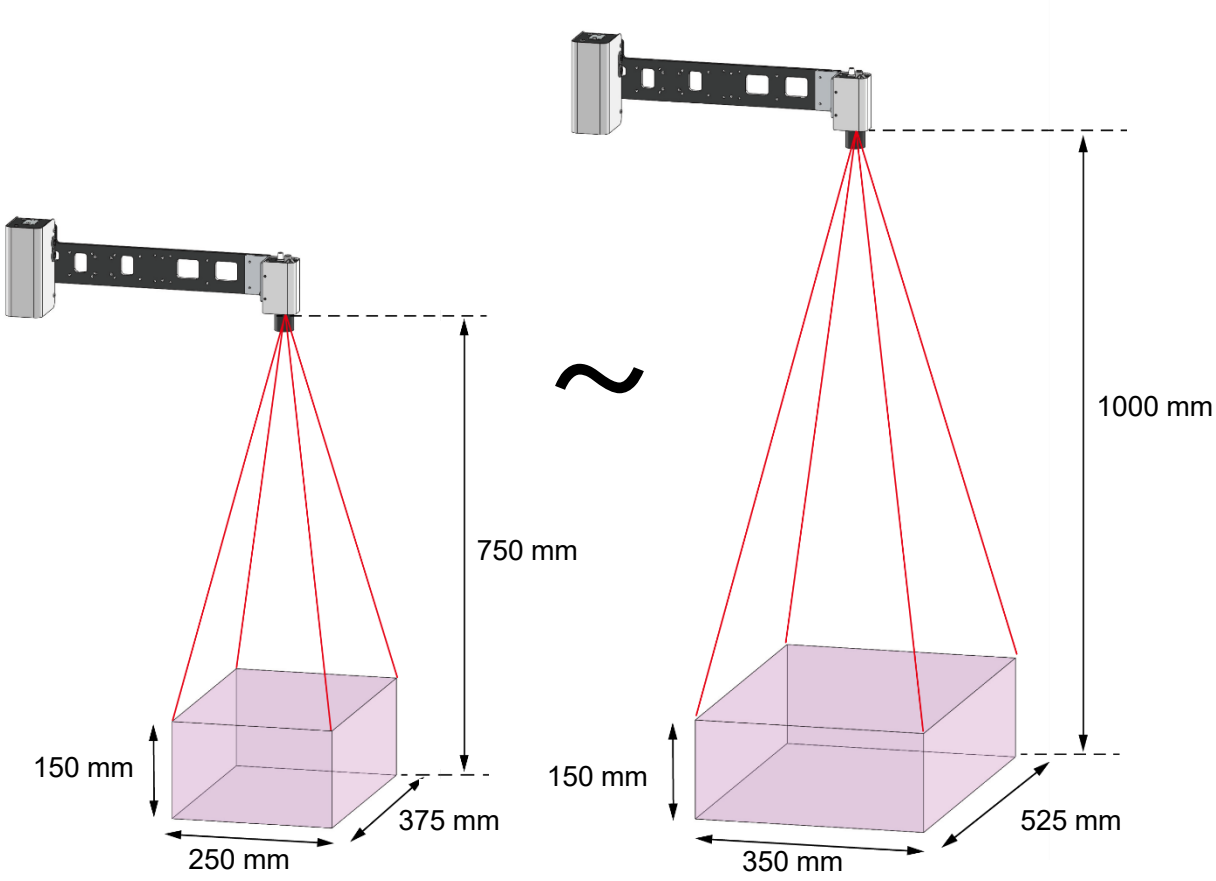


Fig. 3-22 Measurement view when attaching a camera to the mounting base (large) <ii> in Fig. 3-9 with an optional lens for enlarged view

3.5.4. 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.

3.5.5. Network security

MELFA-3D Vision operates in a network environment, but access to the edge computer is restricted. For further advanced security, contact us. A paid service can be provided.

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.

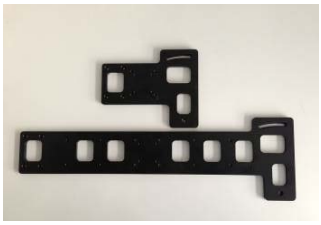
Table 4-1: MELFA-3D Vision product configuration list

No.	Parts name	Model name		Qty	Remarks
(1)	Camera head (with dedicated communication cable, power cable, and lens)	2F-3DVS2-HEAD2		1	Power cable: Discrete cable
(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)	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)
(4)	MELFA-3D Vision software ・MELFA-3D Vision software installer ・Instruction manual ・Sample program ・Software license agreement	3F-52C-WIN		1	
(5)	Shield cover	MTFX-15 Note 6		1	8.3 (L) (m)
(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-OPT3		1	Optional [(1)+(2)+(3)+(5)]
(8)	MELFA Smart Plus card pack (AB type)	2F-DQ520		Either one	Optional CR800 controller use only
	MELFA Smart Plus card (B type)	2F-DQ521			

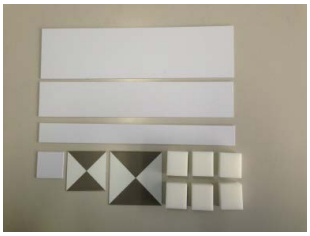
Note 1: The jig is different on each side. Use with the matte surface facing up.
Note 2: Z calibration plate
Note 3: XY calibration plate
Note 4: XY and robot calibration plate
Note 5: Raising block
Note 6: Zippertubing (Japan) Ltd.

(1) Camera head

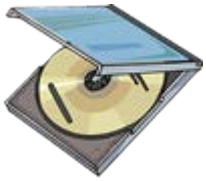
(2) Mounting base set
(The small one is attached to (1) when the product is shipped.)



(3) Calibration jig



(4) MELFA-3D Vision software



(5) Shield cover

(6) Extended Field of view option

(8) MELFA Smart Plus card pack or MELFA Smart Plus card

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)	Edge computer	OS: Windows 10 Professional/Enterprise (64bit) CPU: Intel Core i7 (4 cores or more) RAM: 4 [GB] or more Note 1 HDD: 100 [GB] or more Gigabit Ethernet port × 1	1	For MELFA-3D Vision software Note 1: When using the MELFA-3D Vision extended function, select 8 [GB] or more, and when not using the function, select 4 [GB] or more.
(2)	Computer	Computer with RT ToolBox3 installed * Operating condition of RT ToolBox3	1	For setting (Can be used with 1)
(3)	Switching hub	1000BASE-T or higher	1	* Devices whose operation has been confirmed ・Mitsubishi Electric intelligent hub (NZ2MHG-T8F2) ・Mitsubishi Electric industrial switching hub (NZ2EHG-T8N) ・NETGEAR switching hub (GS308P/GS316) ・ELECOM switching hub (EHC-G05MN/EHC-G08MN/EHC-G16MN)
(4)	LAN cable	Category 5e or higher	3	・Between 1) and 3) ・Between 2) and 3) ・Between the robot controller and 3) * Use 2 cables when using 1) and 2).
(5)	24 V DC power supply	TDK-Lambda RWS50B-24 (Refer to "4.2.1 Recommended 24 V DC power supply specifications".)	1	For camera head

◇◆◇If using a LAN hub◇◆◇

A Gigabit Ethernet compatible hub must be used. Note that if a non-compatible hub is used between the computer and the edge computer, the display of live images on RT ToolBox3 delays.

4.2.1. Recommended 24 V DC power supply specifications

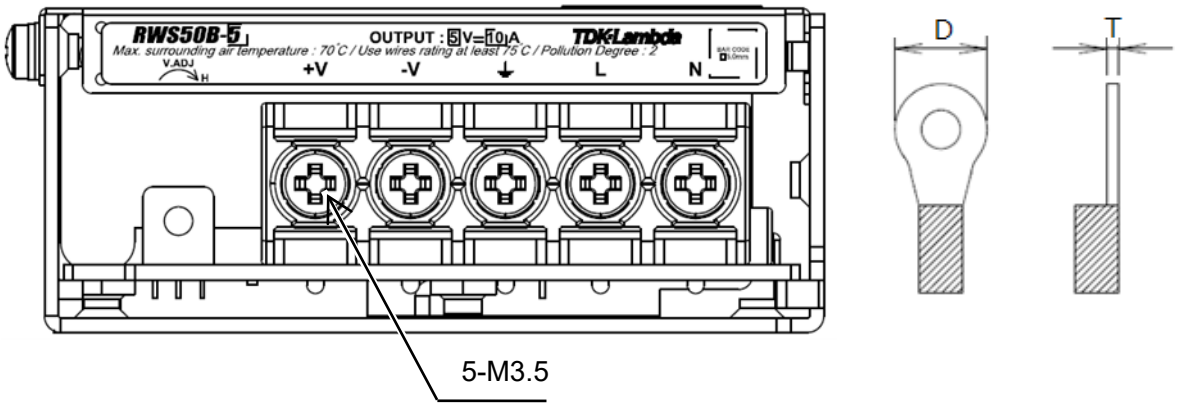
The following shows the specifications of the recommended 24 V DC power supply prepared by customer.

Table 4-3 24 V DC power supply specifications

Item		Unit	Specification	Remarks
Manufacturer		-	TDK-Lambda Corporation	
Model		-	RWS50B-24	
Input	Voltage	Vac	85 to 265	
	Current	A	1.1 typ	ACIN 100 V
			0.7 typ	ACIN 200 V
	Frequency	Hz	50/60(47 to 63)	
Output	Rated voltage	Vdc	24	
	Maximum current	A	2.2	
	Voltage setting accuracy	Vdc	21.6 to 27.6	
External dimensions		mm	34 (W)×81.5 (D)×82 (H)	
Weight		g	230	
Operating temperature range		°C	-20 to +70	–20 °C :50%, –10 to +45 °C :100%, +70 °C :20%
Operation humidity		%RH	30 to 90	No dew condensation

[Note] When using a power supply other than the recommended model, use the power supply of 50 W or higher.

Recommended 24 V DC power supply (prepared by customer)
Recommended model: RWS50B-24
Manufacturer: TDK-Lambda



Wire color	Wire size	Crimped terminal (MAX)	Display at power supply
Blue (+24 V)	AWG21	D: 8.1mm T: 1.0mm *1	+V
Yellow (SG)			−V
FG			⏚
Prepared by customer			L
			N

* 1 When fastening both of 2 crimped terminals, use the ones of T: 0.8 mm.

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 Note3	CR750-Q/CR751-Q Note2	Ver.R6e or later Note1
	CR750-D/CR751-D Note2	Ver.S6e or later Note1
	CR800-D/CR800-R/CR800-Q	Ver.A1 or later Note4

Note 1: For CR750/CR751 series controllers, the upper limit of the recognized number of pieces for model-less recognition changes depending on the software version.

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

Note 2: The MELFA-3D Vision extended functions cannot be used in the CR750/CR751 series controllers.
Note 3: The system status variable M_V3Rmn1/M_V3Rmn2 cannot be used for MELFA-BASIC V.
Note 4: For Ver. A3 or earlier, the MELFA-3D Vision extended function or system status variable M_V3Rmn1/M_V3Rmn2 cannot be used.

■ Supported software

Parts name	Model name
MELSOFT RT ToolBox3	3F-14C-WINJ 3F-14C-WINE
MELSOFT RT ToolBox3 mini	3F-15C-WINJ 3F-15C-WINE
MELSOFT RT ToolBox3 Pro	3F-16D-WINJ 3F-16D-WINE

• Versions compatible with RT ToolBox3/mini/Pro

Versions of RT ToolBox 3 that are compatible with MELFA-3D Vision differ depending on the version of MELFA-3D Vision you are using. Refer to the table below to check that you are using software versions that are compatible with each other.

MELFA-3D Vision version	Compatible version
Ver. 2.0.0	Ver. 1.30G or later
Ver. 2.0.1	Ver. 1.70Y or later

■ How to check the MELFA-3D Vision software version

To check the software version of MELFA-3D Vision, access the MELFA-3D Vision installation folder (the default installation folder is "C:\Program Files\MITSUBISHI ELECTRIC\MELFA-3D Vision"). Right-click MELFA_EYE.exe, then go to [Properties] → [Details] → [File version].

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 "3.4 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.

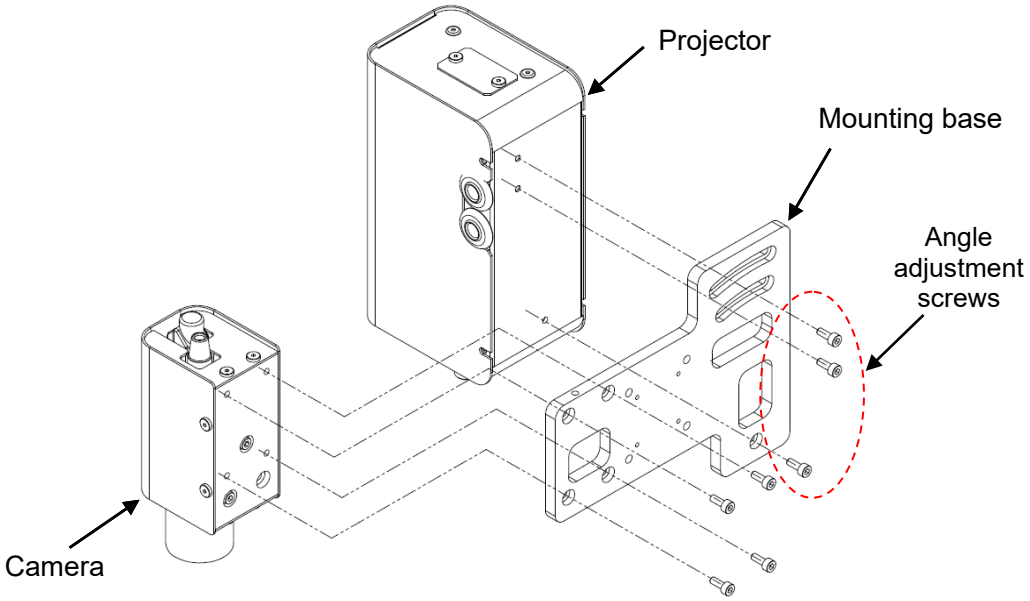


Fig. 5-1 Mounting base (small) attachment

Select the camera attachment position depending on the workpiece distance (see Fig. 3-13).

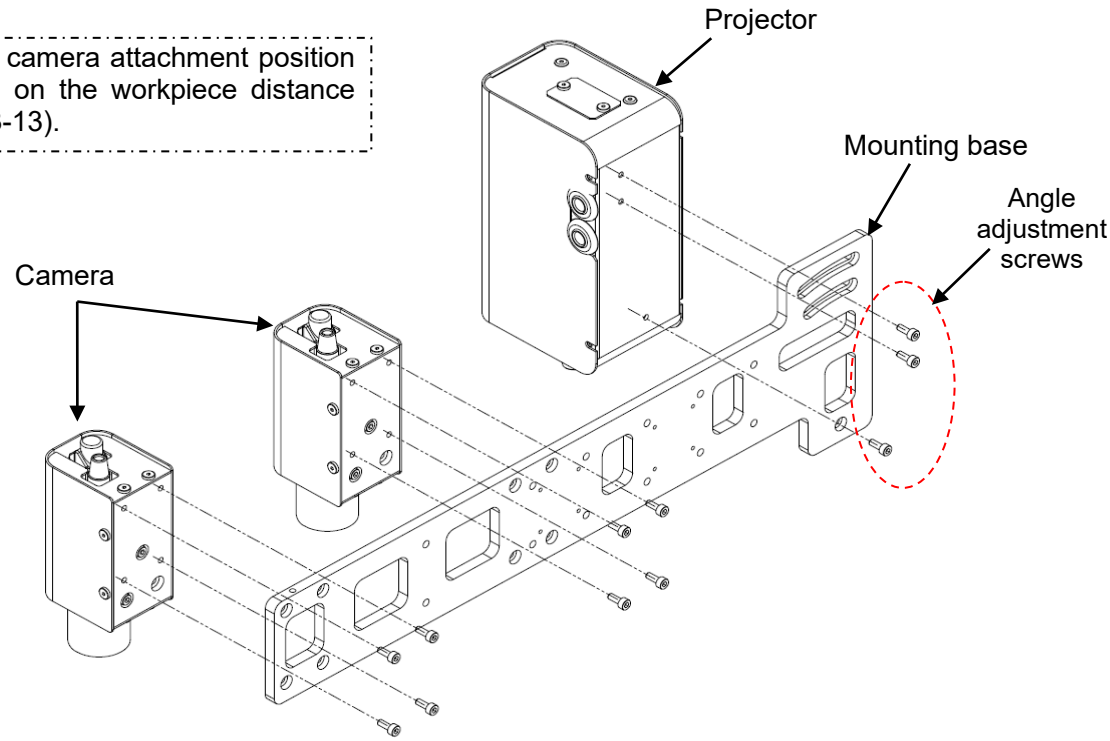


Fig. 5-2 Mounting base (large) attachment

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.

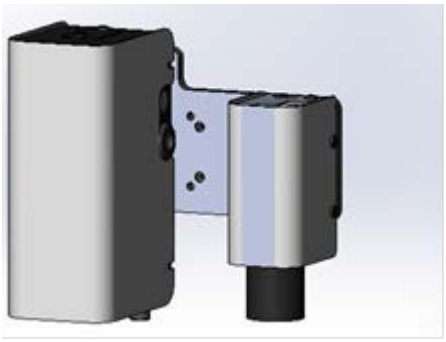


Fig. 5-3 Standard configuration (factory setting)

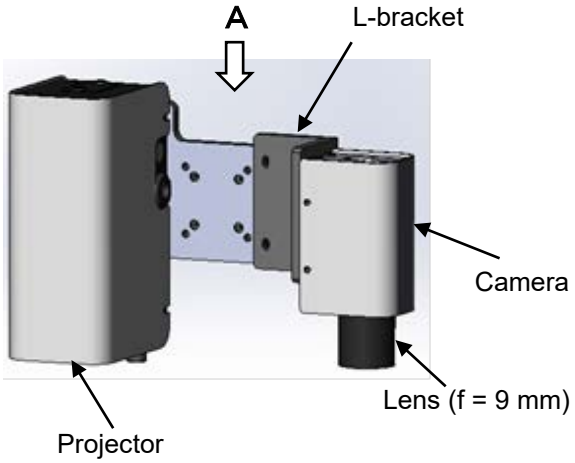
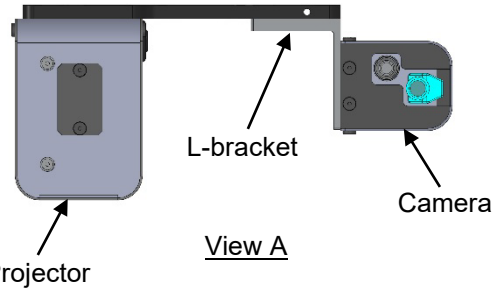


Fig. 5-4 Enlarged view configuration



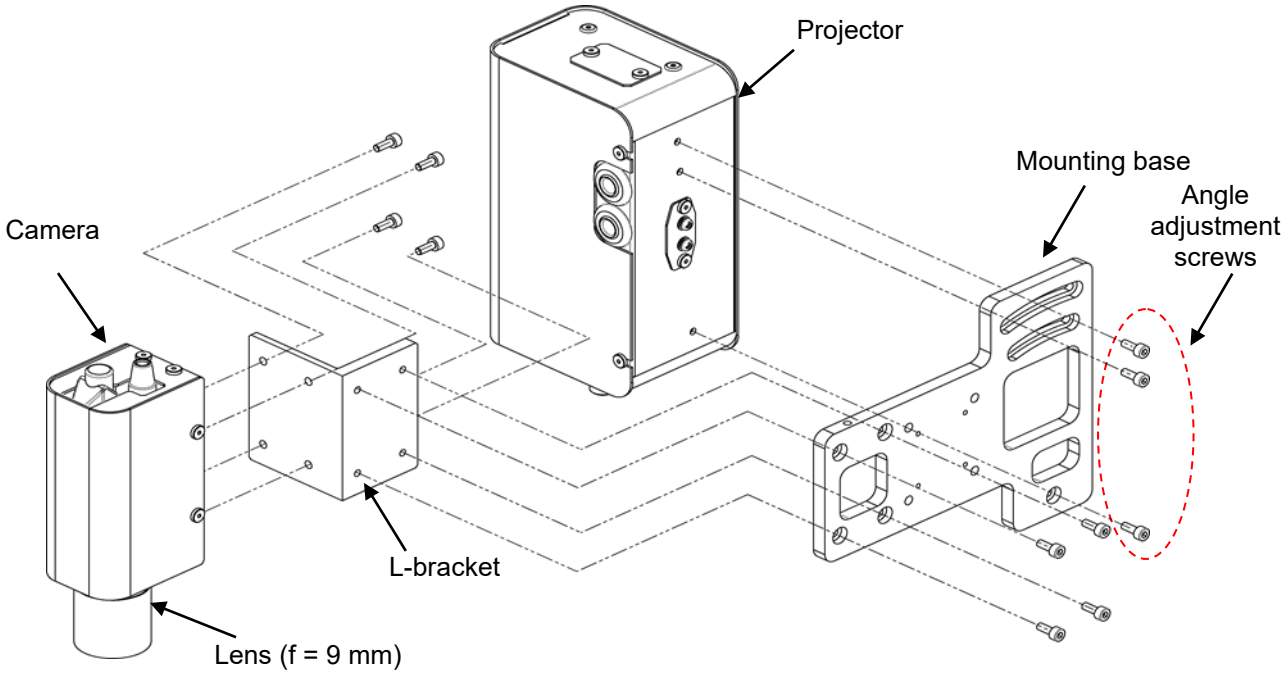


Fig. 5-5 Enlarged view option installation

Note 1: The mounting base (small) is attached at factory setting.

◇◆◇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 ToolBox3 MELFA-3D Vision settings screen.

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.

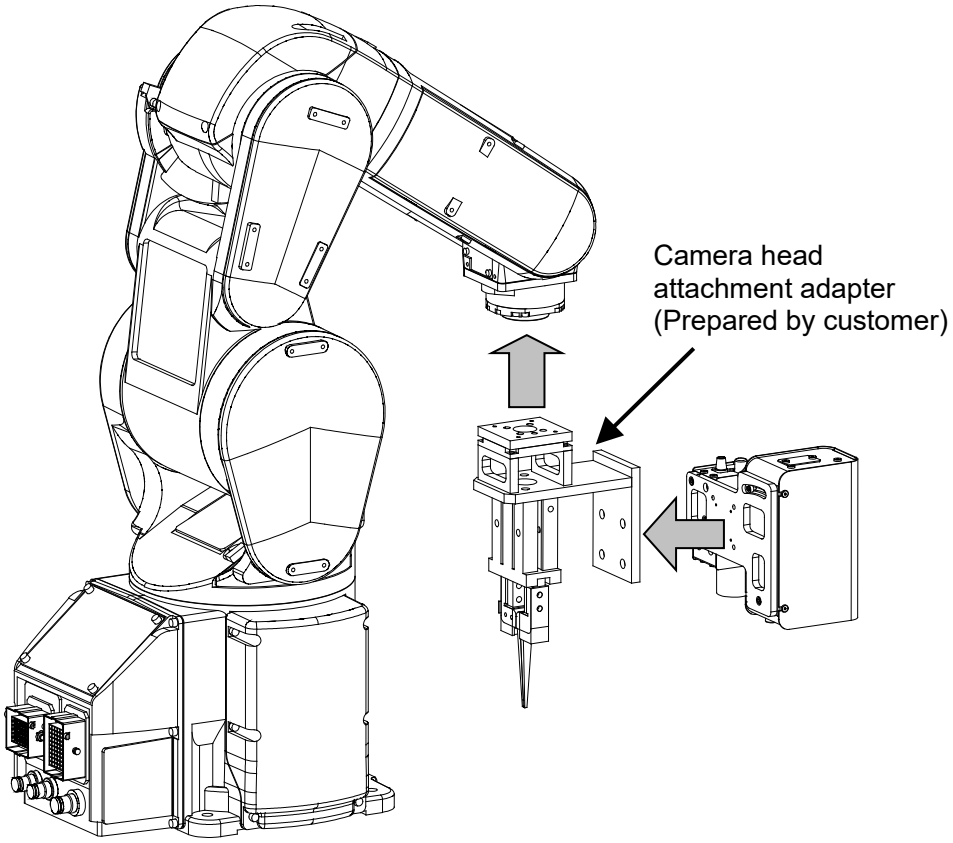


Fig. 5-6 Hand eye attachment example

◇◆◇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

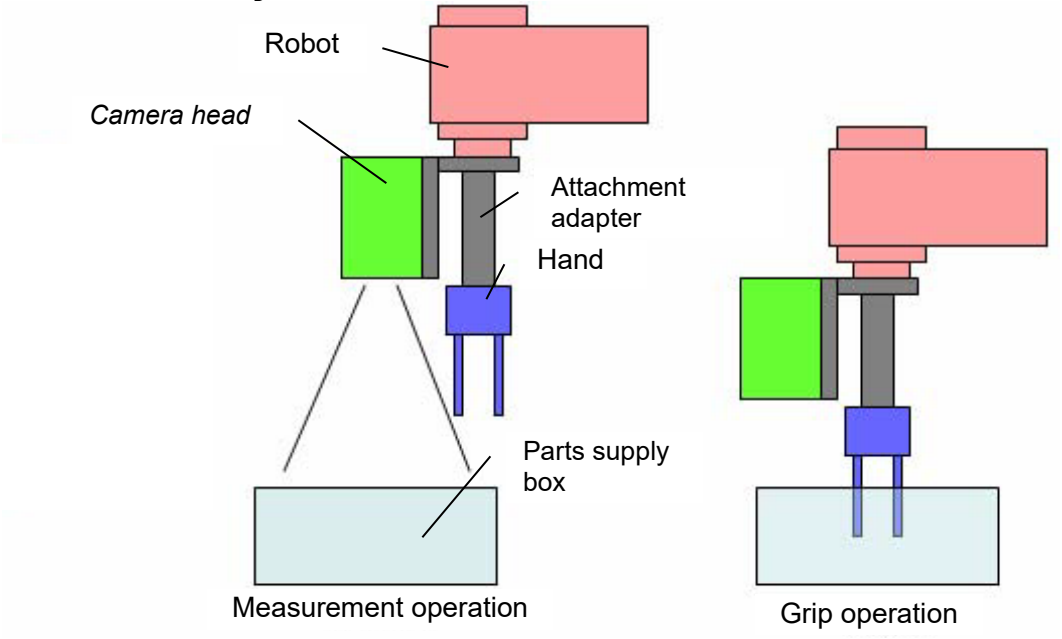


Fig. 5-7 Hand eye

<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

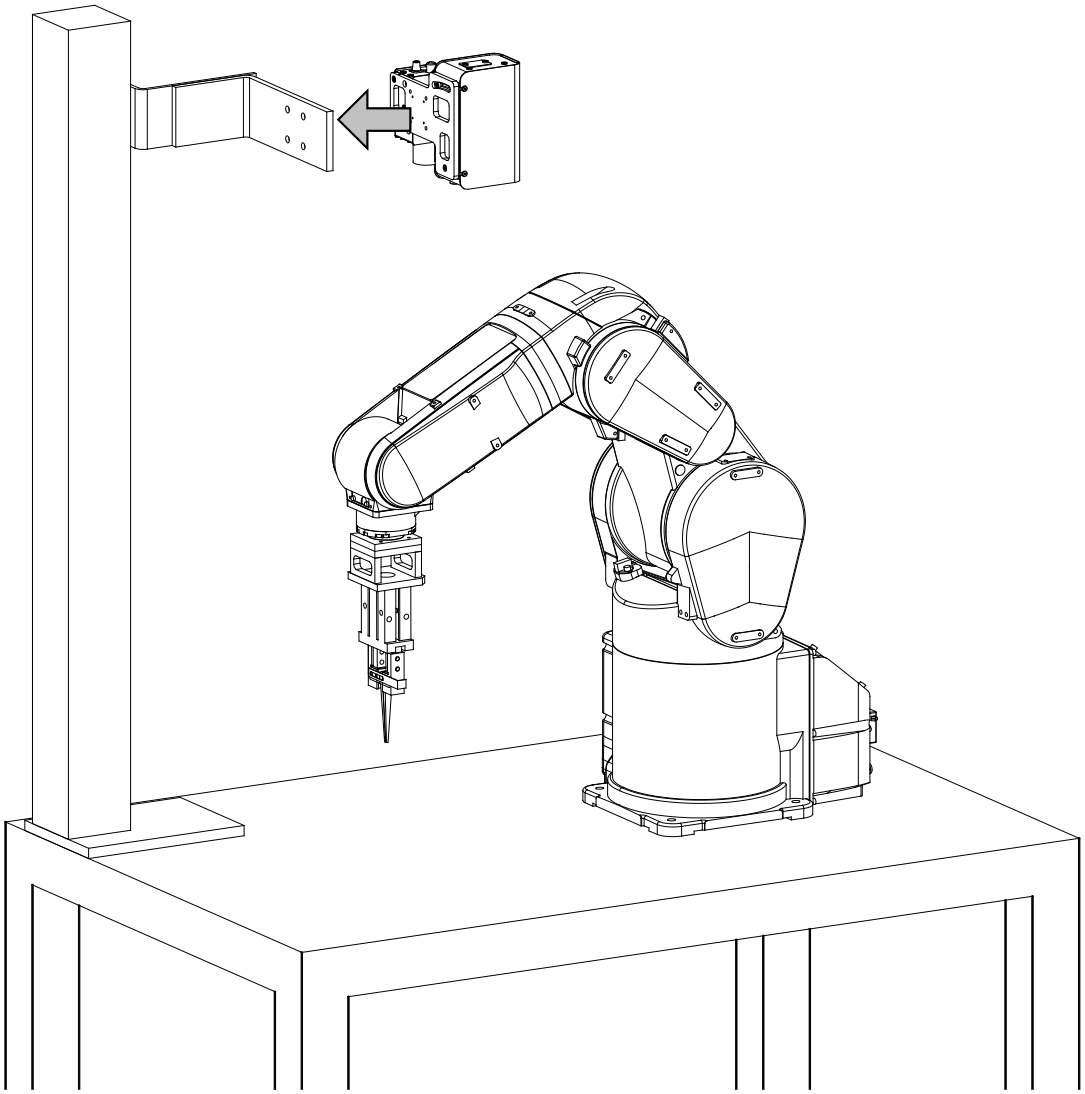


Fig. 5-8 Fixed camera attachment example

◇◆◇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

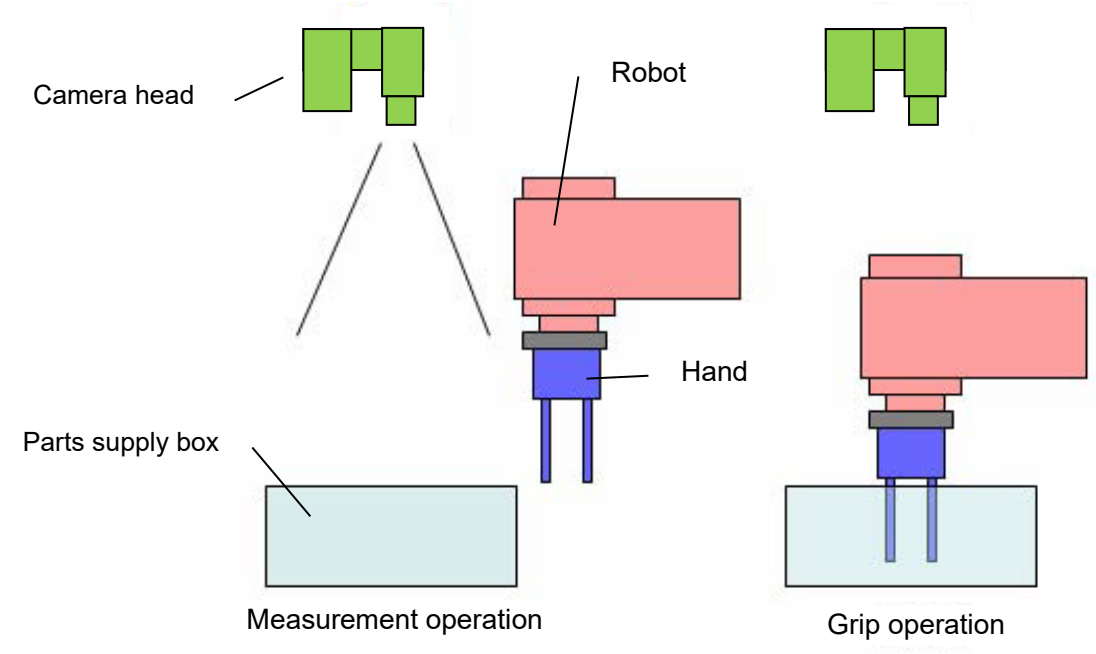


Fig. 5-9 Fixed camera

<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.

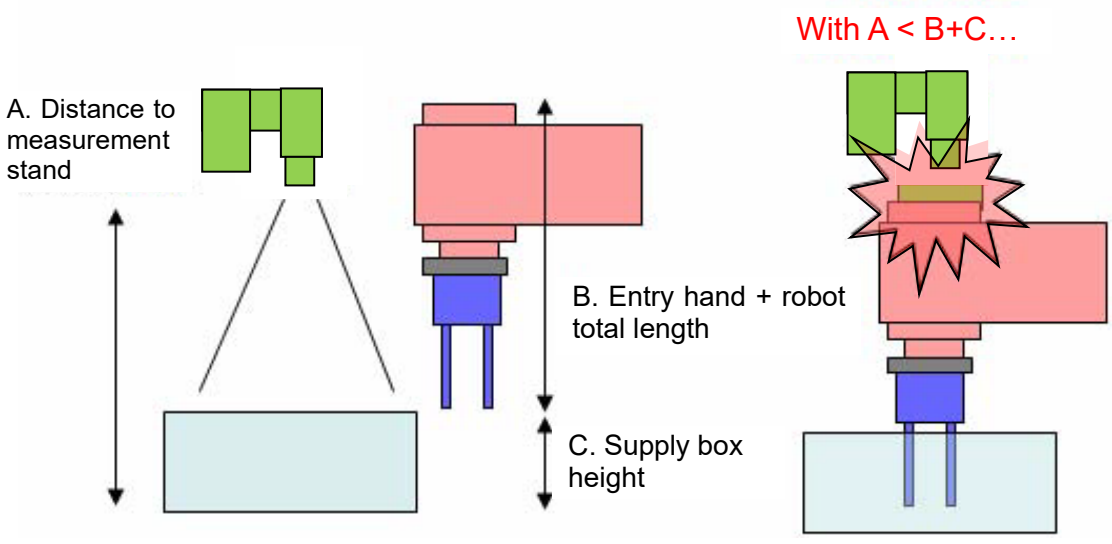


Fig. 5-10 Fixed camera demerits

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, camera head to edge computer to robot controller connection, and wiring.

6.1. Connection of Equipment

Connect the camera head and robot controller as shown in Fig. 6-1 to Fig. 6-3.

◇◆◇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>

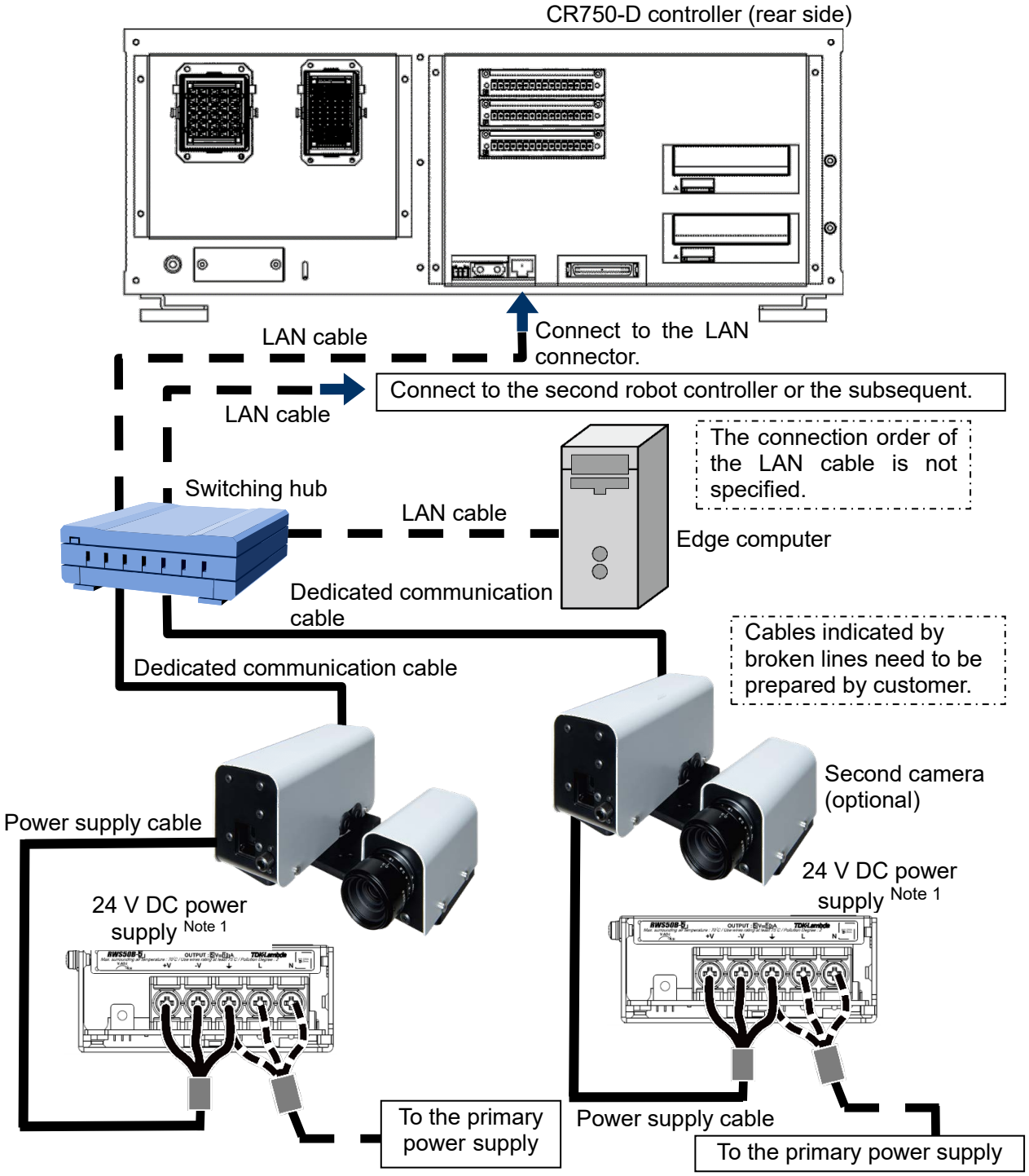


Fig. 6-1 Cable connection (CR750-D series)

<CR751-D series>

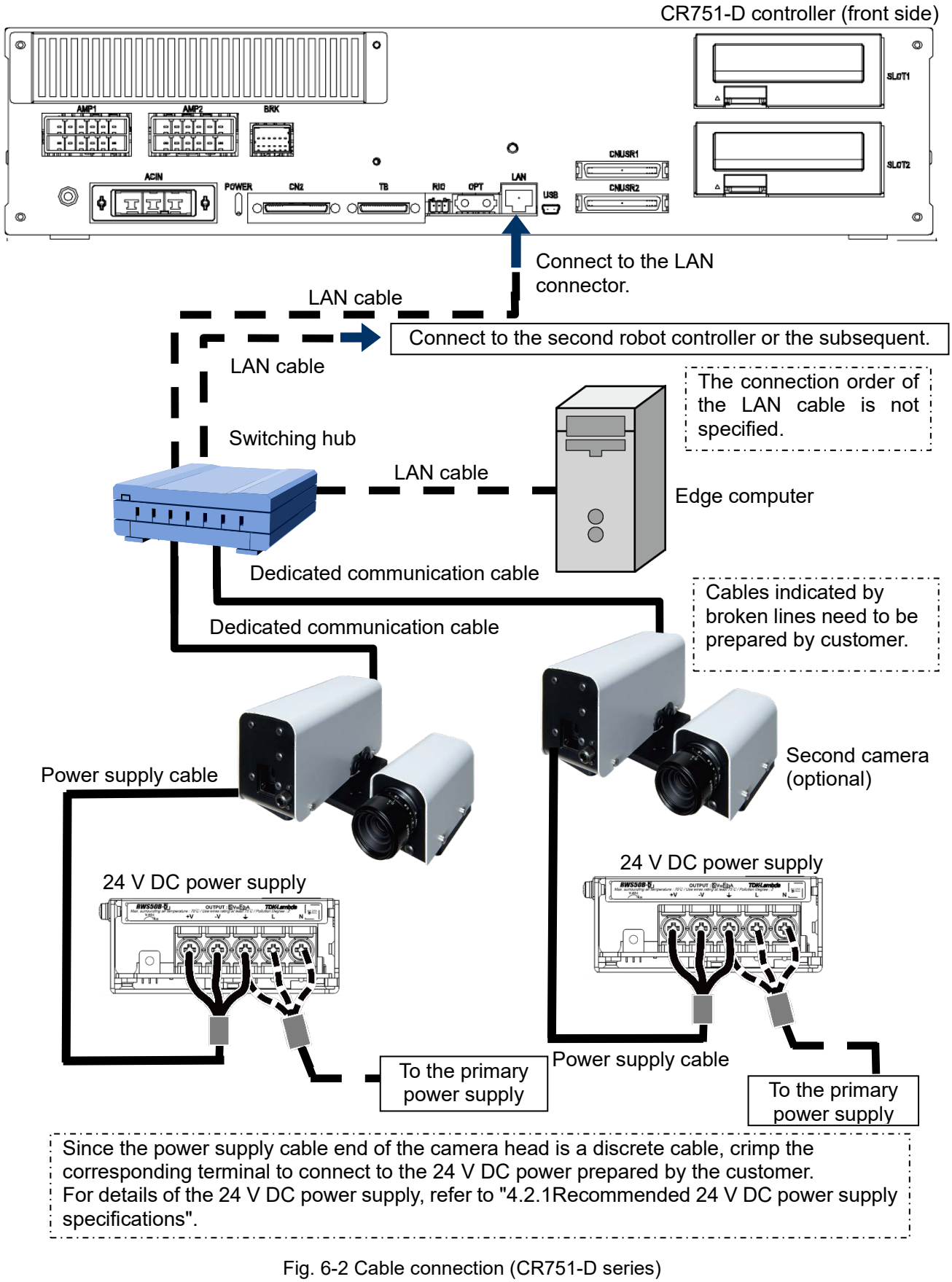


Fig. 6-2 Cable connection (CR751-D series)

<CR800-Q/CR750-Q/CR751-Q series>

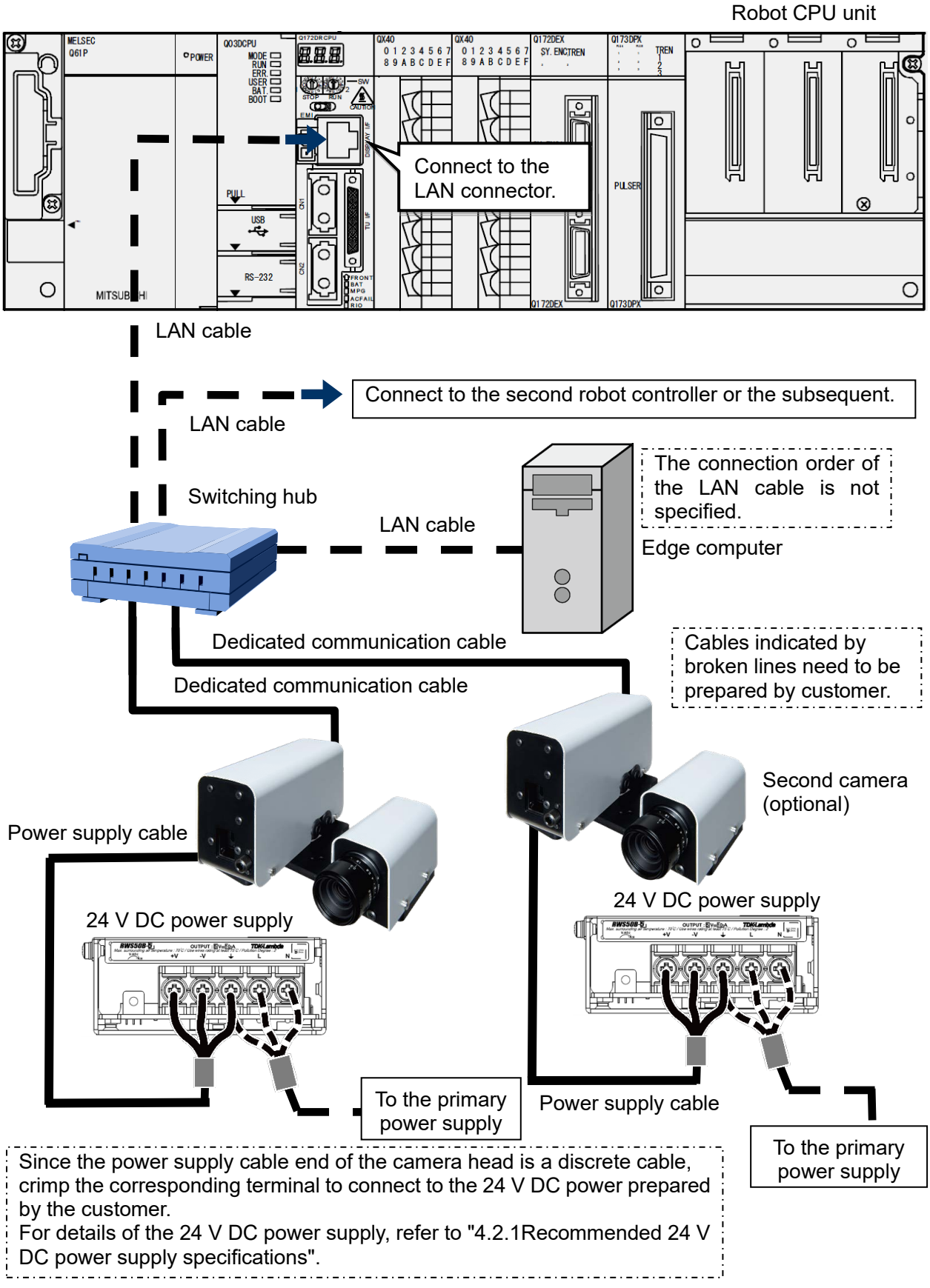


Fig. 6-3 Cable connection (CR800-Q/CR750-Q/CR751-Q series)

<CR800-D series>

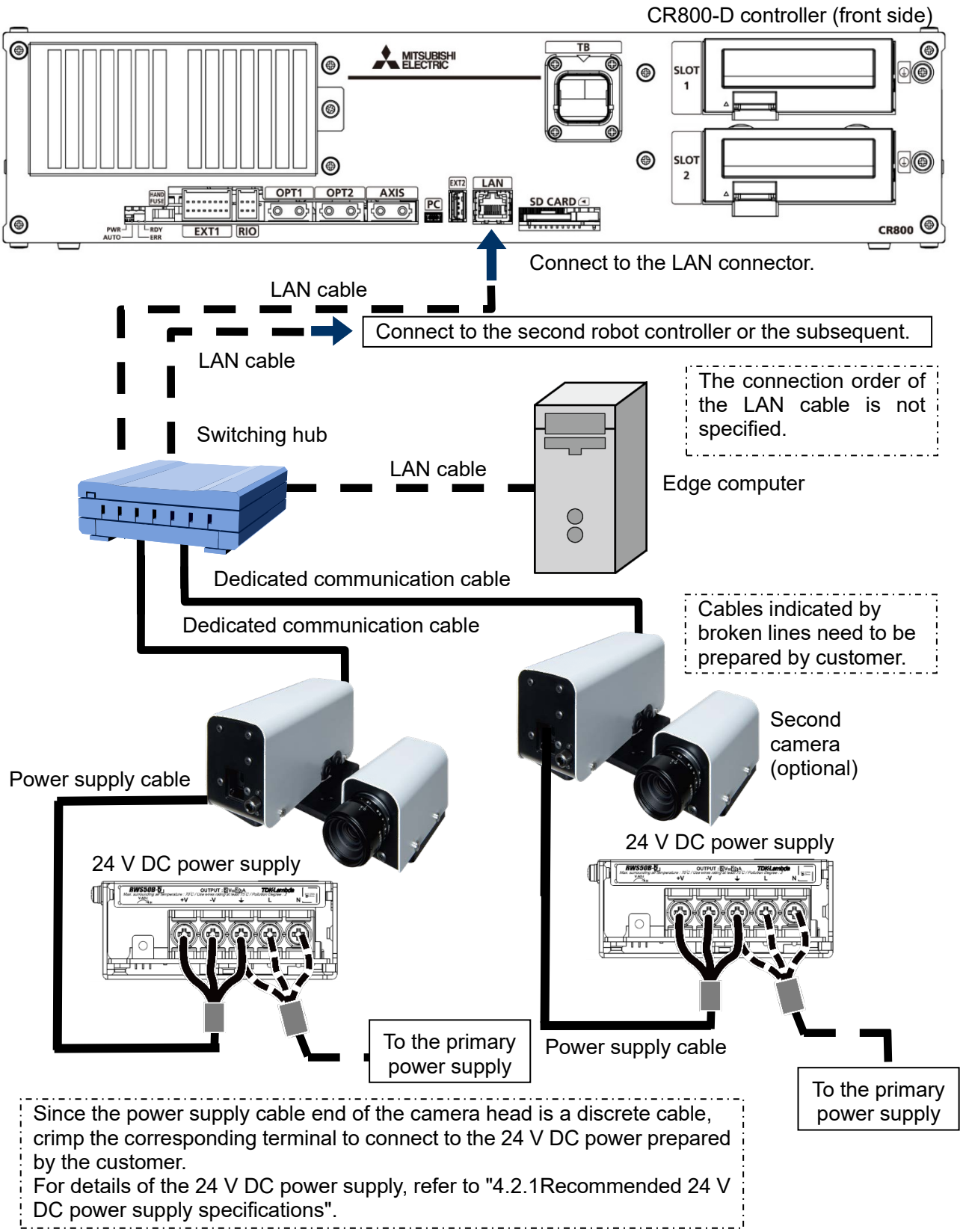


Fig. 6-4 Cable connection (CR800-D series)

<CR800-R series>

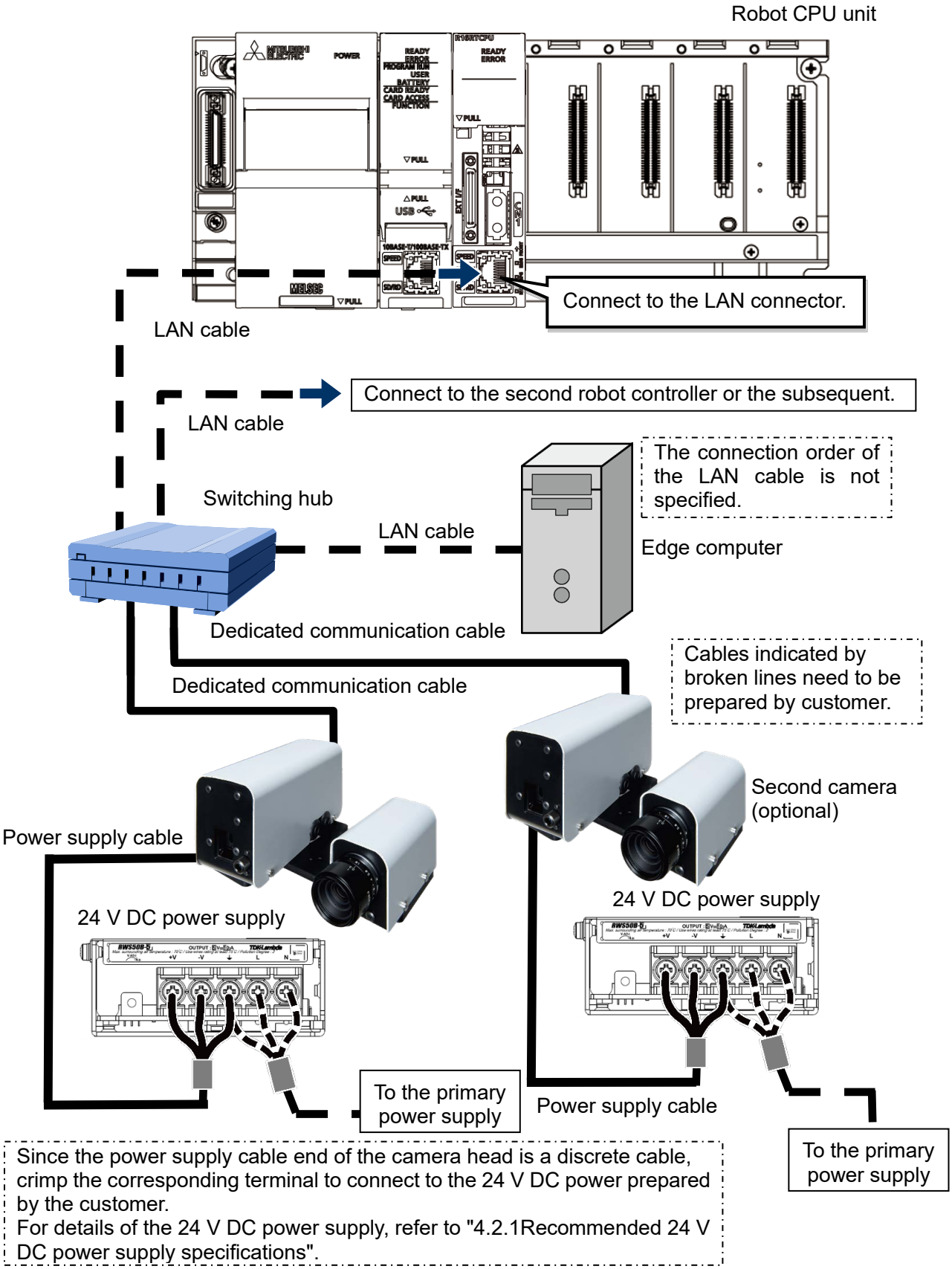


Fig. 6-5 Cable connection (CR800-R series)

6.2. Wiring of Equipment

Connect the edge computer and camera head as shown in the following figure. When attaching a shield cover for cable protection and measure against noise, attach it from edge computer side. Avoid the part that moves at the robot operation. (Refer to the following figure.)

6.2.1. Hand eye

Secure the power supply cable and dedicated communication cable between the edge computer and the camera head around the robot. When doing so, secure so that the cable is not stretched when the robot moves. When wiring the power cable, fix the power cable to the robot using the method specified in the figure to reduce the influence of noise. Please note that this system is not compatible with internal wiring specifications..

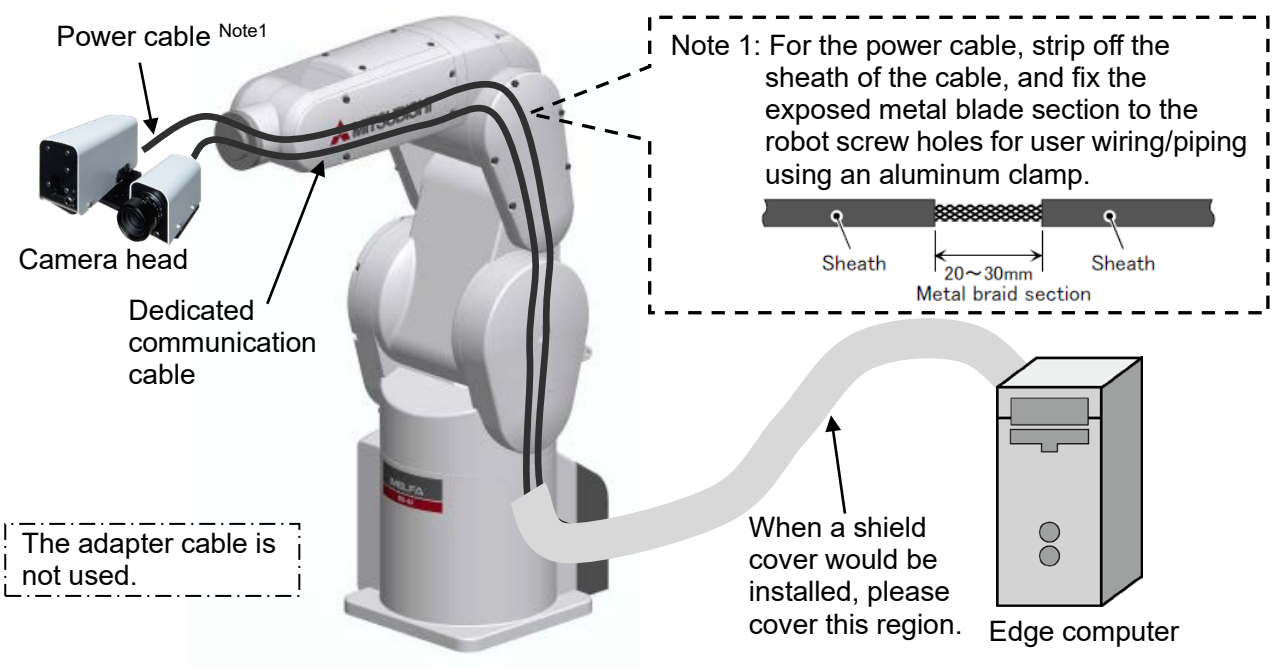


Fig. 6-6 Wiring example for hand eye

6.2.2. Fixed camera

When wiring the power cable, fix the power cable using the method specified in the figure to reduce the influence of noise.

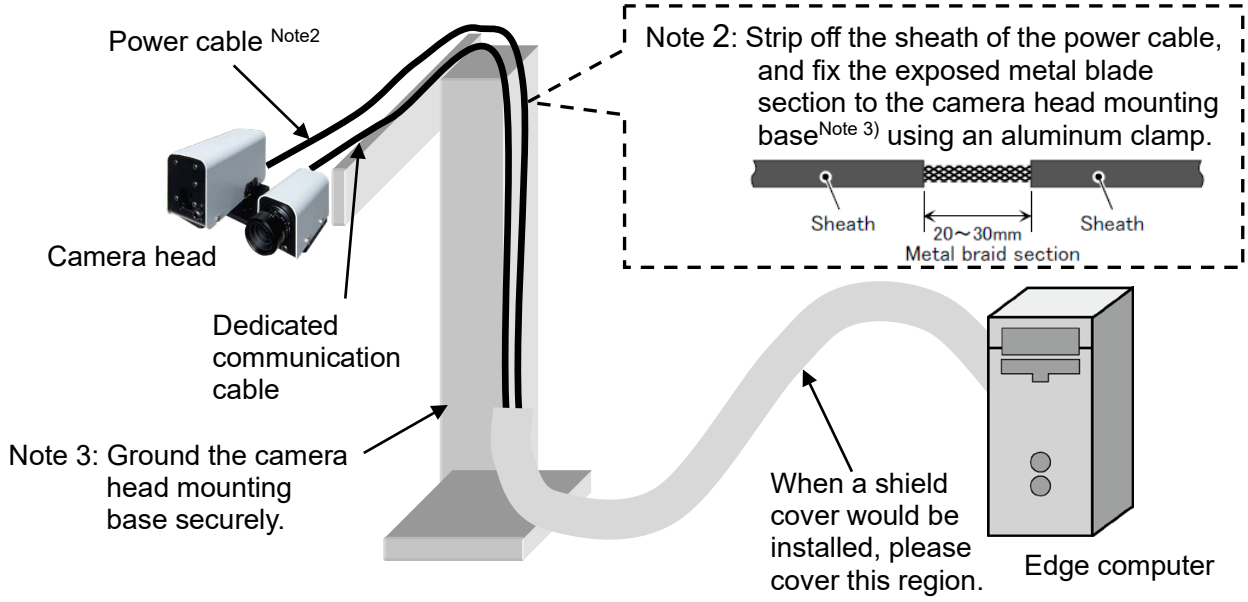


Fig. 6-7 Wiring example for fixed camera

7. USING MELFA-3D VISION

7.1. Installation Procedure

The following shows the procedure for starting MELFA-3D Vision.

Camera head attachment (Refer to "Chapter 5 CAMERA HEAD ATTACHMENT".)

↓

Connection and wiring of equipment (Refer to "Chapter 6 CONNECTION AND WIRING OF EQUIPMENT".)

↓

MELFA-3D Vision software installation (Refer to "Section 7.1.1 MELFA-3D Vision software installation procedure".)

↓

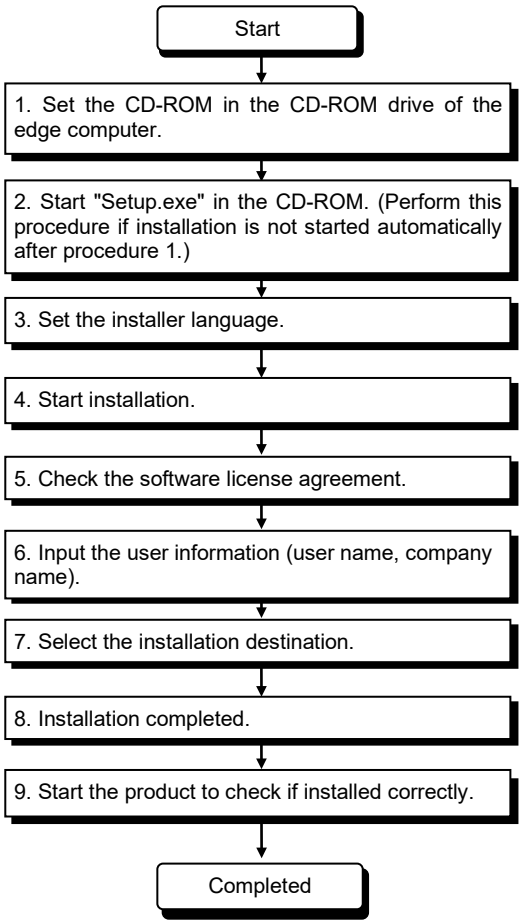
RT ToolBox3 installation (Refer to "RT ToolBox3 User's Manual".)

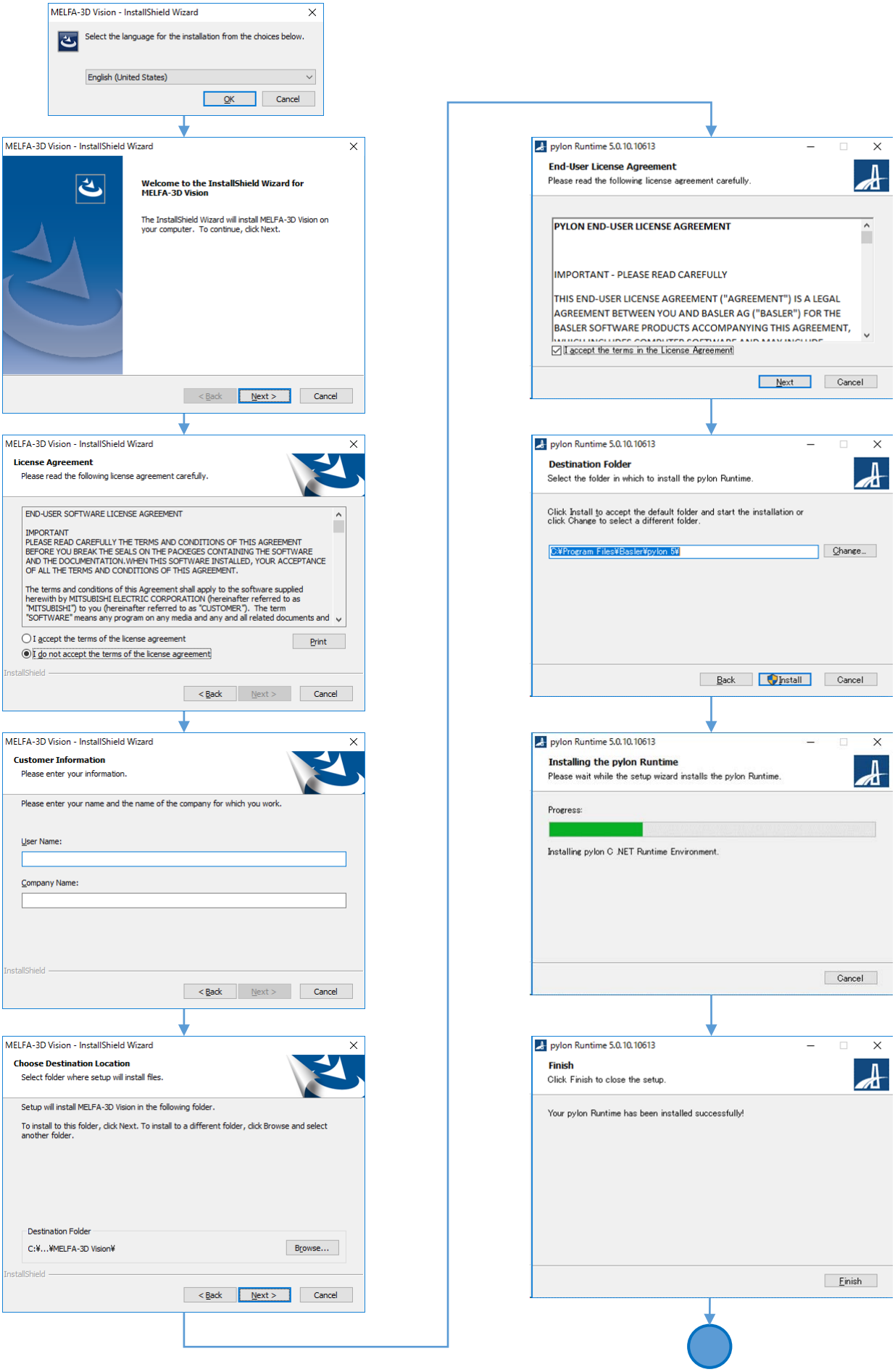
↓

MELFA Smart Plus card or card pack setting (When using the MELFA-3D Vision extended functions)

7.1.1. MELFA-3D Vision software installation procedure

Install to the edge computer by the following procedure.




MELFA-3D Vision - InstallShield Wizard
Select the language for the installation from the choices below.
English (United States)
OK
Cancel
MELFA-3D Vision - InstallShield Wizard
Welcome to the InstallShield Wizard for MELFA-3D Vision
The InstallShield Wizard will install MELFA-3D Vision on your computer. To continue, click Next.
< Back
Next >
Cancel
MELFA-3D Vision - InstallShield Wizard
License Agreement
Please read the following license agreement carefully.
END-USER SOFTWARE LICENSE AGREEMENT
IMPORTANT
PLEASE READ CAREFULLY THE TERMS AND CONDITIONS OF THIS AGREEMENT BEFORE YOU BREAK THE SEALS ON THE PACKEGES CONTAINING THE SOFTWARE AND THE DOCUMENTATION.WHEN THIS SOFTWARE INSTALLED, YOUR ACCEPTANCE OF ALL THE TERMS AND CONDITIONS OF THIS AGREEMENT.
The terms and conditions of this Agreement shall apply to the software supplied herewith by MITSUBISHI ELECTRIC CORPORATION (hereinafter referred to as "MITSUBISHI") to you (hereinafter referred to as "CUSTOMER"). The term "SOFTWARE" means any program on any media and any and all related documents and
I accept the terms of the license agreement
I do not accept the terms of the license agreement
Print
InstallShield
< Back
Next >
Cancel
MELFA-3D Vision - InstallShield Wizard
Customer Information
Please enter your information.
Please enter your name and the name of the company for which you work.
User Name:
Company Name:
InstallShield
< Back
Next >
Cancel
MELFA-3D Vision - InstallShield Wizard
Choose Destination Location
Select folder where setup will install files.
Setup will install MELFA-3D Vision in the following folder.
To install to this folder, click Next. To install to a different folder, click Browse and select another folder.
Destination Folder
C:¥...¥MELFA-3D Vision¥
Browse...
InstallShield
< Back
Next >
Cancel
pylon Runtime 5.0.10.10613
End-User License Agreement
Please read the following license agreement carefully.
PYLON END-USER LICENSE AGREEMENT
IMPORTANT - PLEASE READ CAREFULLY
THIS END-USER LICENSE AGREEMENT ("AGREEMENT") IS A LEGAL AGREEMENT BETWEEN YOU AND BASLER AG ("BASLER") FOR THE BASLER SOFTWARE PRODUCTS ACCOMPANYING THIS AGREEMENT,
I accept the terms in the License Agreement
Next
Cancel
pylon Runtime 5.0.10.10613
Destination Folder
Select the folder in which to install the pylon Runtime.
Click Install to accept the default folder and start the installation or click Change to select a different folder.
C:¥Program Files¥Basler¥pylon 5¥
Change...
Back
Install
Cancel
pylon Runtime 5.0.10.10613
Installing the pylon Runtime
Please wait while the setup wizard installs the pylon Runtime.
Progress:
Installing pylon C .NET Runtime Environment.
Cancel
pylon Runtime 5.0.10.10613
Finish
Click Finish to close the setup.
Your pylon Runtime has been installed successfully!
Finish

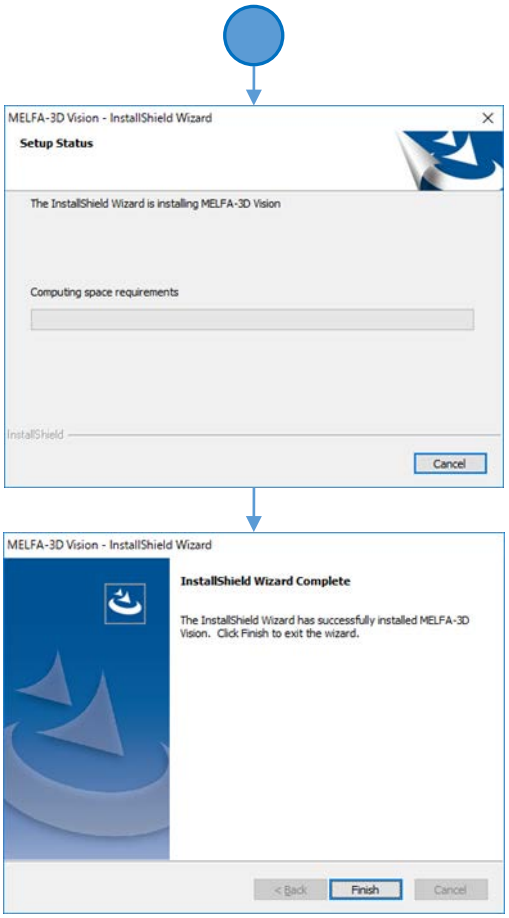


Fig. 7-1 MELFA-3D Vision software installation procedure

7.2. IP Address Preparation

An IP address is necessary for the edge computer and camera head. If connecting to a network, contact the network administrator beforehand to obtain IP addresses.

7.3. Turning ON the Camera Head

By turning ON the camera head, the start screen shown in Fig. 7-2 appears.

Fig. 7-2 Start screen at the time of power-on

7.4. MELFA-3D Vision Application Startup

Select [MELFA-3D Vision] in the startup menu to start the application.
MELFA-3D Vision is stored in the task tray after startup.
If the camera setting is completed, pattern irradiation is performed once.

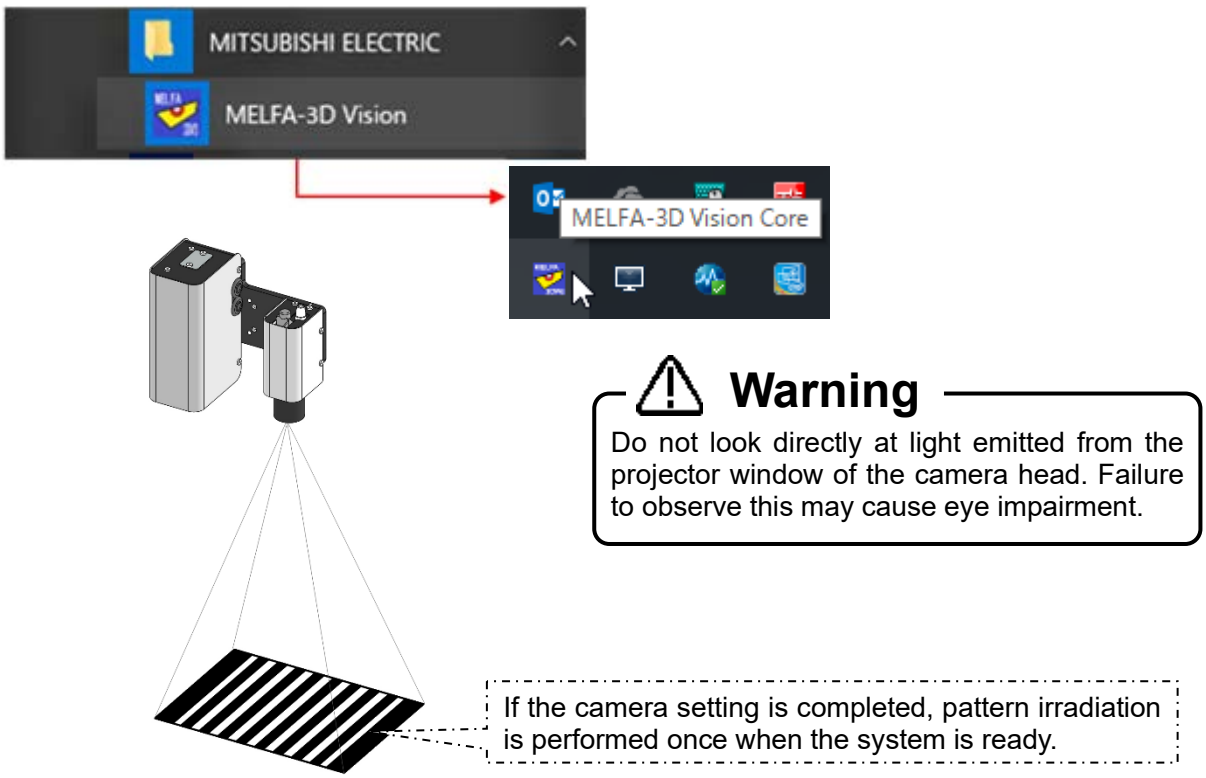


Fig. 7-3 MELFA-3D Vision application startup method

7.5. MELFA-3D Vision Application Exit

Right-click the [MELFA-3D Vision] icon in the task tray to display the context menu, and select the [Exit] menu to exit.

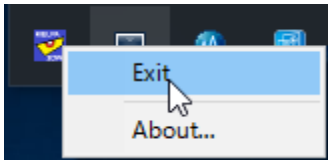


Fig. 7-4 MELFA-3D Vision application exit method

7.6. RT ToolBox3 Startup

RT ToolBox3 is required to specify MELFA-3D Vision settings. Double-click the desktop shortcut to start RT ToolBox3, or click the [Start] button, and select [All programs] - [MELSOFT] - [RT ToolBox3].


RT ToolBox3

Fig. 7-5 RT ToolBox3 shortcut

7.7. When Using the MELFA-3D Vision Extended Function

When using the extended functions such as automatic adjustment of the recognition setting, insert the MELFA Smart Plus card or Smart Plus card pack into the robot controller, and set the parameters and function codes. (CR800 controller use only)

CAUTION

The MELFA-3D Vision extended functions cannot be used in the CR750/CR751 series controllers.

(1) Turn OFF the robot controller power.

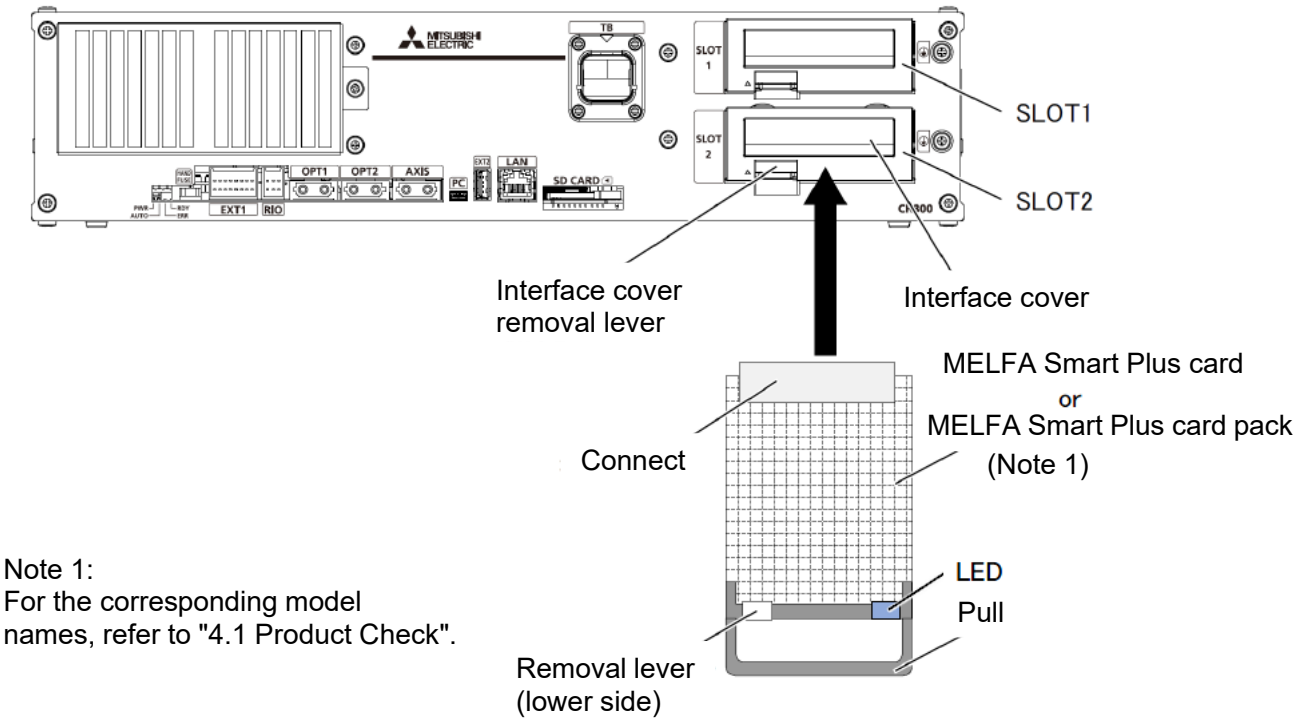
- CR800-D type : (1) Turn OFF the earth leakage breaker switch.
- CR800-R/Q type : (1) Turn OFF the robot CPU system power.
  (2) Turn OFF the earth leakage breaker switch.

(2) Insert the "MELFA Smart Plus card" or "MELFA Smart Plus card pack" into the robot controller. (For the corresponding model names, refer to "4.1 Product Check".)

(1) Pinch the interface cover removal lever and pull out the interface cover.

(2) Hold the pull of the MELFA Smart Plus card and insert it into SLOT1 or SLOT2.
At this time, insert the card so that the both ends of the card fit into the grooves of the slot (SLOT1 and SLOT2 in Fig. 7-6).

(3) Insert the connector fully into the slot until the removal lever is locked with clicking sound.



Note 1:
For the corresponding model names, refer to "4.1 Product Check".

Fig. 7-6 Insertion of the MELFA Smart Plus card (MELFA Smart Plus card pack)

CAUTION

Insert only one MELFA Smart Plus card.
When multiple MELFA Smart Plus cards are inserted, the LED does not blink, and the error (L3782) occurs. For the error details, refer to "10.3 MELFA Smart Plus Card Related Error Details".

(3) Turn ON the robot controller power.

・CR800-D type : (1) Turn ON the earth leakage breaker switch.
(The POWER lamp of the robot controller blinks.)

・CR800-R/Q type : (1) Turn ON the earth leakage breaker switch.
(2) The POWER lamp of the robot controller blinks.
(3) After that, turn ON the robot CPU system power.

(4) For the MELFA Smart Plus card, set the parameters for enabling MELFA-3D Vision.

[When using the MELFA Smart Plus card]

Only one function supported by the card used can be used. Therefore, setting the parameters for enabling MELFA Smart Plus and MELFA-3D Vision and restarting the robot controller are not required.

Use the teaching pendant or RT ToolBox3 to set the parameters.
When using RT ToolBox3, connect RT ToolBox3 to the controller using MELFA-3D Vision.

(1) Change the setting value of the parameter "SMART+1" to [101].

(2) Restart the robot controller.

・CR800-D type : Turn ON the earth leakage breaker switch.

・CR800-R/Q type : Turn OFF the robot CPU system power.
→Turn OFF the earth leakage breaker switch.
→Turn ON the earth leakage breaker switch.
→Turn ON the robot CPU system power after the POWER lamp of the robot controller blinks.

(3) The LED blinks in green when MELFA-3D Vision is enabled.

[When using the MELFA Smart Plus card pack]

・Configuring this setting and restarting the robot controller are not required. Proceed to step (5).
・Check that the LED of the MELFA Smart Plus card pack blinks in blue.

(5) Set the function code of the MELFA Smart Plus card.

[When setting the function code for RT ToolBox3 connected to the actual device]

(1) Start RT ToolBox3 and connect it to the actual device.

(2) Select [Option] in the [Workspace] tab in RT ToolBox3.

(3) Select [MELFA Smart Plus] from the tree on the left of the Option window.

(4) When the "Get function code" button is pressed, the function code of the MELFA Smart Plus card is input in the function code column.

(5) Restart RT ToolBox3.

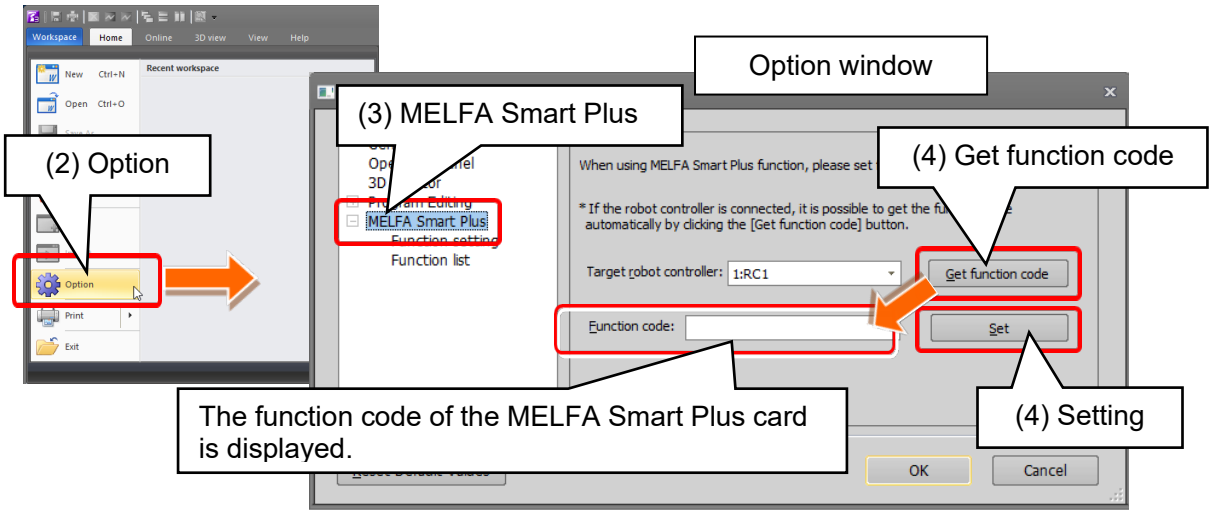


Fig. 7-7 Function code setting of the MELFA Smart Plus card (when connected to the actual device)

[When setting the function code for RT ToolBox3 not connected to the actual device]

(1) Read the value of the parameter "MSPCODE" with the teaching pendant or RT ToolBox3 connected to the actual device. (The value of "MSPCODE" is the function code. It is not displayed when the MELFA Smart Plus card is not inserted.)

(2) Note the displayed value of the parameter "MSPCODE" (24 alphanumeric characters).

(3) In RT ToolBox3 not connected to the actual device, select [Option] in the [Workspace] tab. Select [MELFA Smart Plus] from the tree on the left of the Option window.

(4) Input the function code of the MELFA Smart Plus card obtained at "Step 2" in the "Function code" column and press the Set button.

(5) Restart RT ToolBox3.

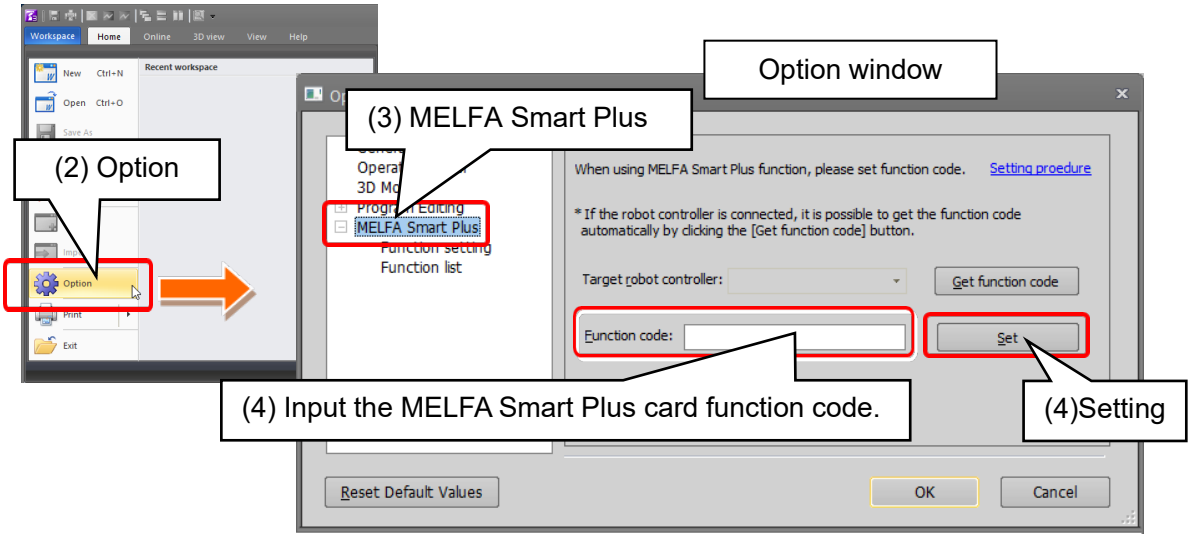


Fig. 7-8 Function code setting of the MELFA Smart Plus card (when not connected to the actual device)

(6) Check that MELFA-3D Vision is enabled.

(1) Select [MELFA Smart Plus] - [Function list] from the tree on the left of the Option window.

(2) The list of valid status of the MELFA Smart Plus functions is displayed on the right.
Check that the state of "Extended function of MELFA-3D Vision" is set to "Enable".

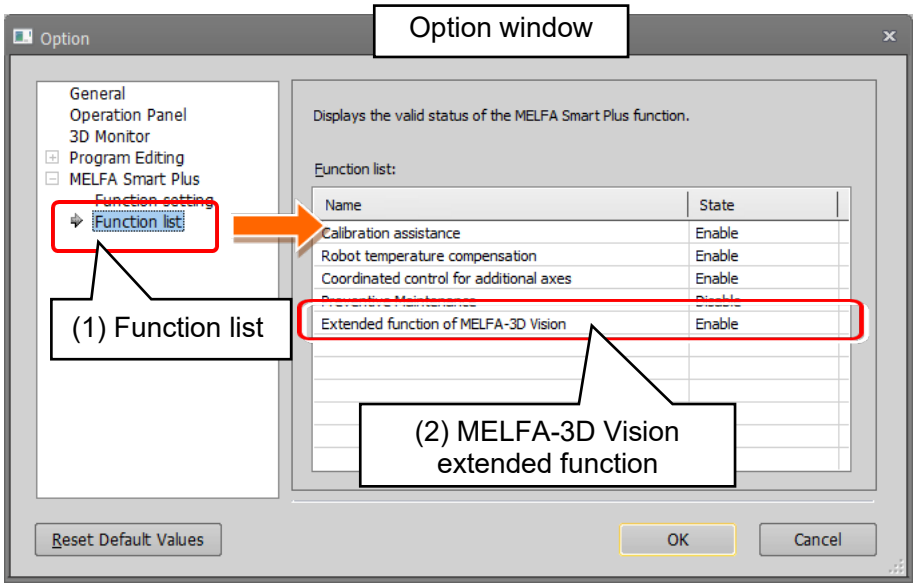


Fig. 7-9 Checking the state of the MELFA-3D Vision extended function

7.8. 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 ToolBox3, [MELFA-3D Vision] appears in the project tree. By pointing [MELFA-3D Vision], [Control unit setting/addition] appears. Double-click this item.

When the Setting and Add Control Unit window opens, the control units on the networks are displayed. If no control unit is displayed, check the connection with the computer and the firewall settings. (Refer to No.1 in 10.5 Q&A.)

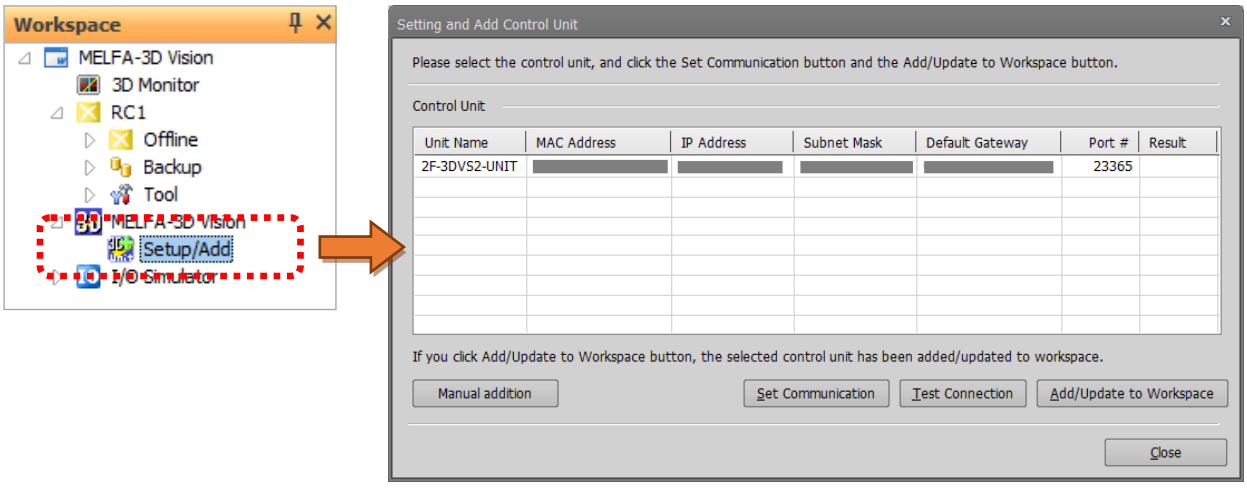


Fig. 7-10 Setting/registration of the control unit

The connection with the control unit whose IP address is determined is possible even if the control unit is not displayed in the list.

There are three methods for setting and adding the control units.
(1) When connecting to the control unit displayed on the window
(2) When connecting to the control unit whose IP address is determined, which is not displayed in the list
(3) When performing the communication settings of the control unit

(1) When connecting to the control unit displayed on the window

Adding a control unit 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.

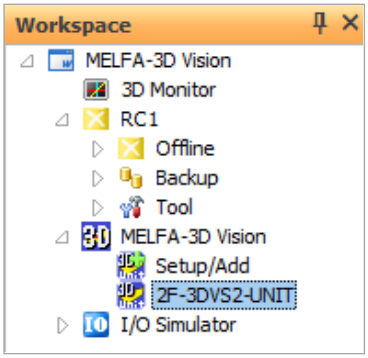


Fig. 7-11 Addition the control unit to the workspace

(2) When connecting to the control unit whose IP address is determined, which is not displayed in the list

The following shows the procedure for registering the settings (unit name/IP address/port number) to the workspace.

Control unit communication settings

Clicking the [Manual addition] button in the Setting and Add Control Unit window displays the [Control Unit Adding] window.

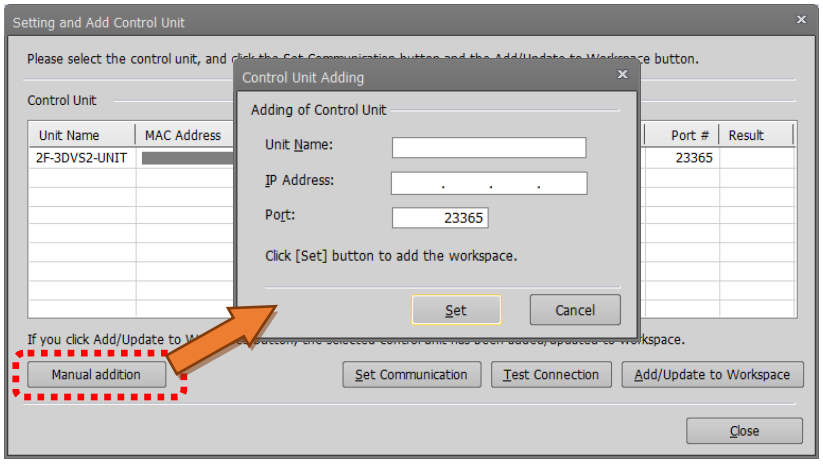


Fig. 7-12 MELFA-3D Vision Setting Screen

Input the unit name and IP address.
Since "23365" is input as an initial value for port number. Press the [Set] button as is.

Input example

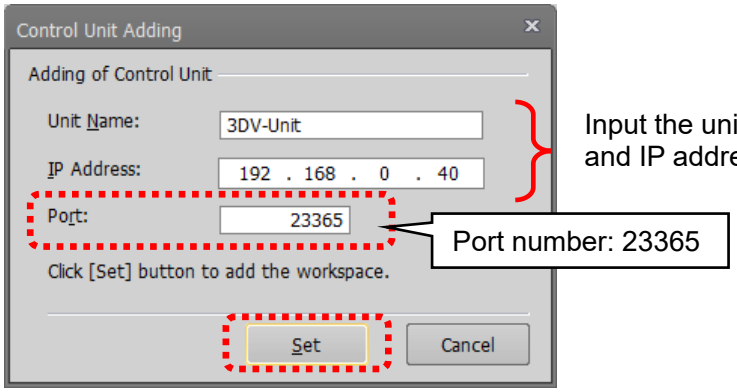


Fig. 7-13 MELFA-3D Vision Setting Screen

The set unit name is added to the project tree of RT ToolBox3.

Input example

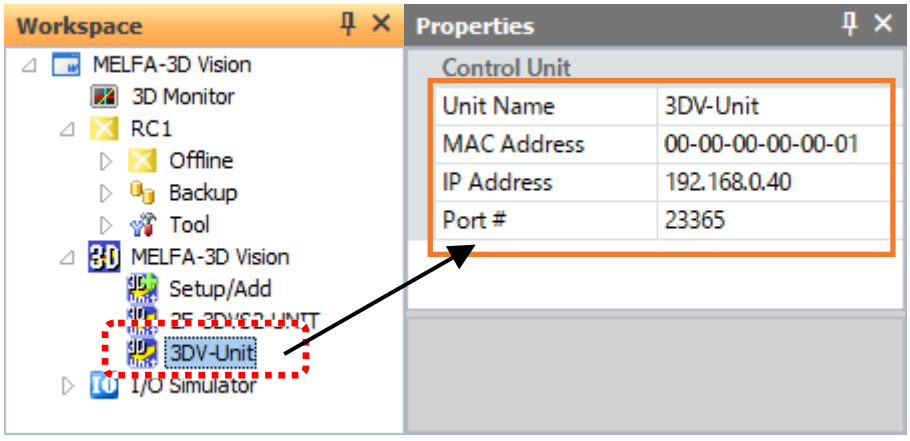


Fig 7-14 MELFA-3D Vision Setting Screen

(3) When performing the communication settings of the control unit

To perform the communication settings, select a control unit displayed in the list, and click the [Set Communication] button to display the communication setting screen for the control unit. At this time, identify the control unit by referring to the MAC address described in the factory setting 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 the name as required. Note 1: Note that [2F-3DVS2-UNIT] is set in Unit Name as an initial setting.

Note 1: Up to 32 alphanumeric characters, spaces, and symbols (except for \/:*?"<>|)

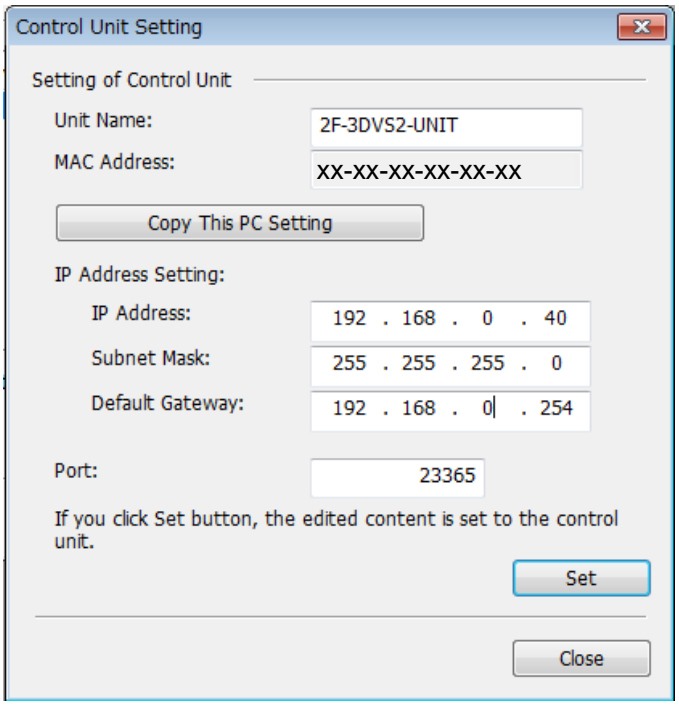


Fig. 7-15 Control unit communication settings

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.

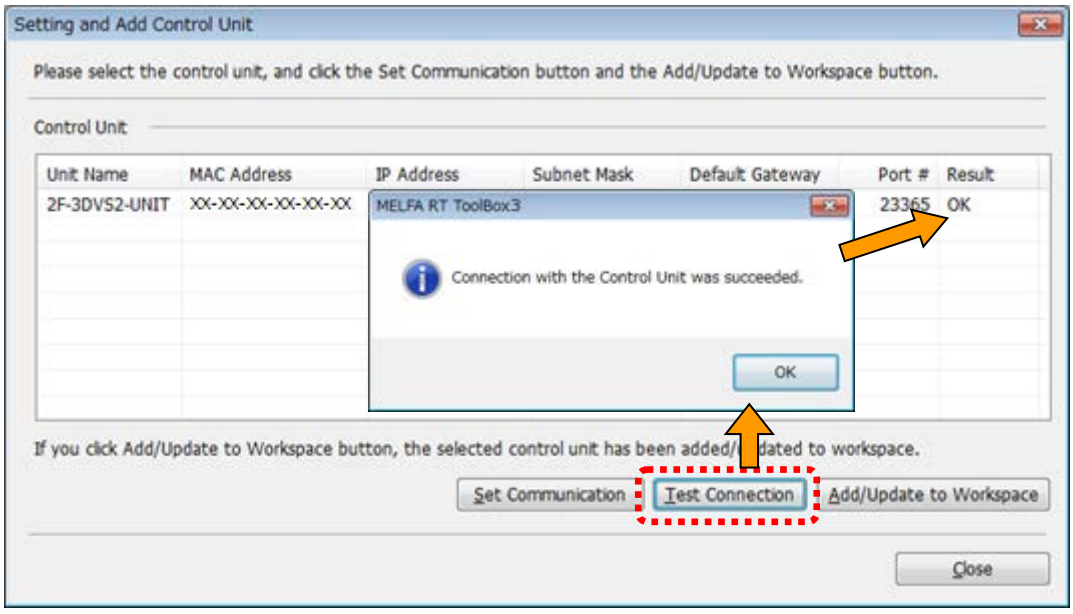


Fig. 7-16 Connection test for the control unit

7.9. MELFA-3D Vision Setting Screen Description

By double-clicking the control unit added to the workspace, the MELFA-3D Vision setting screen (Fig. 7-15) appears.
The MELFA-3D Vision setting screen is configured as follows.

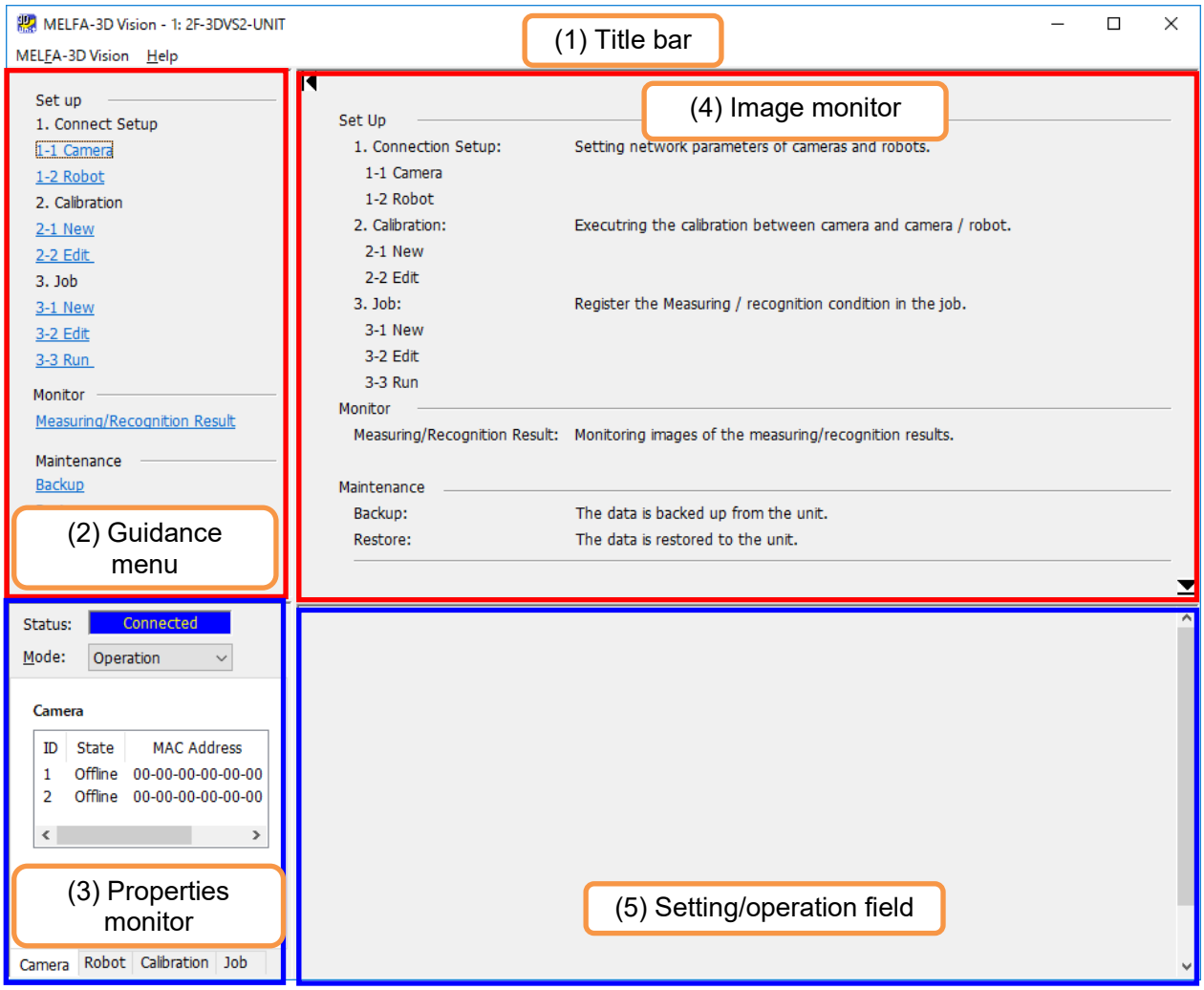


Fig. 7-17 Instructions for the MELFA-3D Vision setting screen

7.9.1. Title bar

The title bar displays the following information.

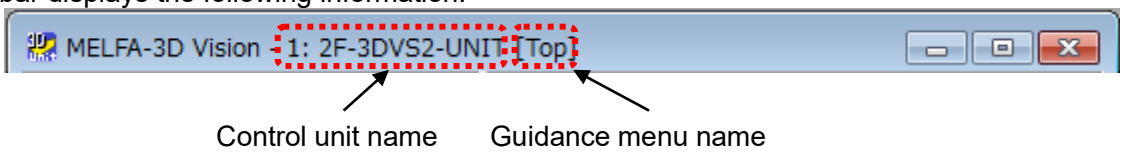


Fig. 7-18 Notation of the title bar for the MELFA-3D Vision setting screen (1)

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

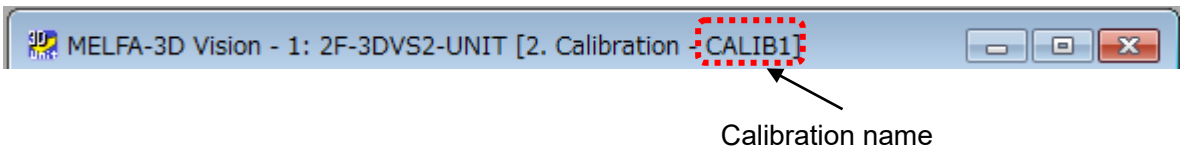


Fig. 7-19 Notation of the title bar for the MELFA-3D Vision setting screen (2)

7.9.2. Properties monitor

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

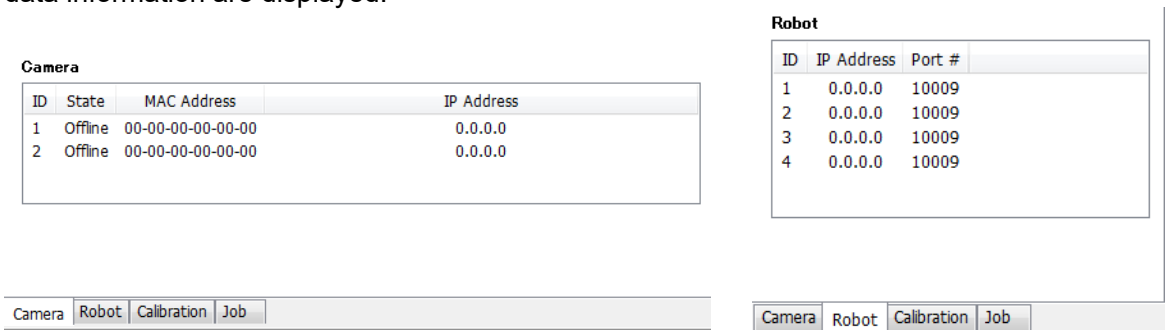


Fig. 7-20 Property monitor (camera, robot)

Table 7-1 Information displayed on the properties monitor (camera)

Item	Description
ID	Camera head ID
State	Displays the connection state with the camera head. (Online/Offline)
MAC Address	Camera head MAC address
IP Address	Camera head IP address (Refer to 7.10.1 Camera settings.)

Table 7-2 Information displayed on the properties monitor (robot)

Item	Description
ID	Robot ID
IP Address	IP address of the connection destination robot (Refer to 7.10.2 Robot settings)
Port#	Port number of the connection destination robot (Refer to 7.10.2 Robot settings)

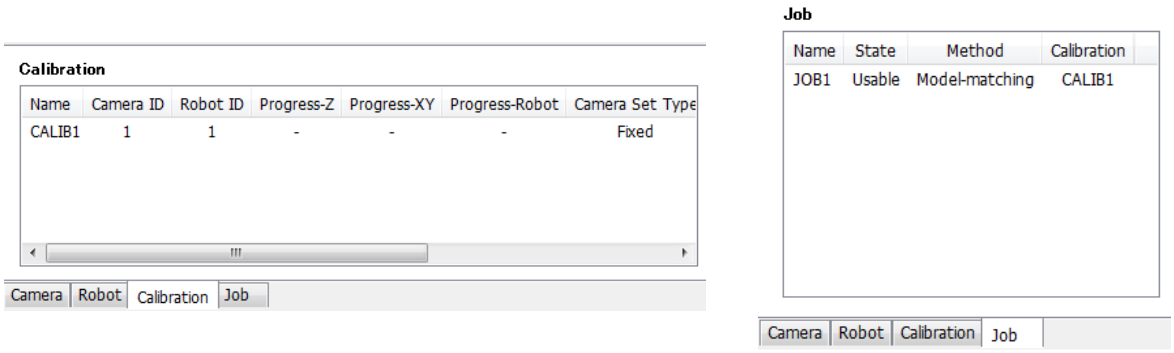


Fig. 7-21 Property monitor (calibration, job)

Table 7-3 Information displayed on the properties monitor (calibration)

Item	Description
Name	Calibration name
Camera ID	Camera ID of the camera head to be used
Robot ID	Robot ID of the robot to be used
Progress-Z	Displays the completion status of the Z calibration.
Progress-XY	Displays the completion status of the XY calibration.
Progress-Robot	Displays the completion status of the robot calibration.
Camera Set Type	Hand: Hand eye Fixed: Fixed camera
Extended Field of view option	Standard (None): Standard mounting Extended: Using the enlarged view option
Robot Calibration	Noncontact Type Contact Type (Refer to the items in Table 7-7 Calibration (initial settings))
Distortion correction	Simple Detail (Refer to the items in Table 7-7 Calibration (initial settings))
Score	Displays the robot calibration score.

Table 7-4 Information displayed on the properties monitor (job)

Item	Description
Name	Job name
State	Enabled/Disabled
Method	Model-less/Model-matching
Name	Name of the calibration to be used

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. 7-22 Control unit connection status

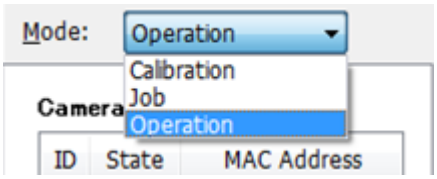


Fig. 7-23 Operation mode change

◇◆◇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.

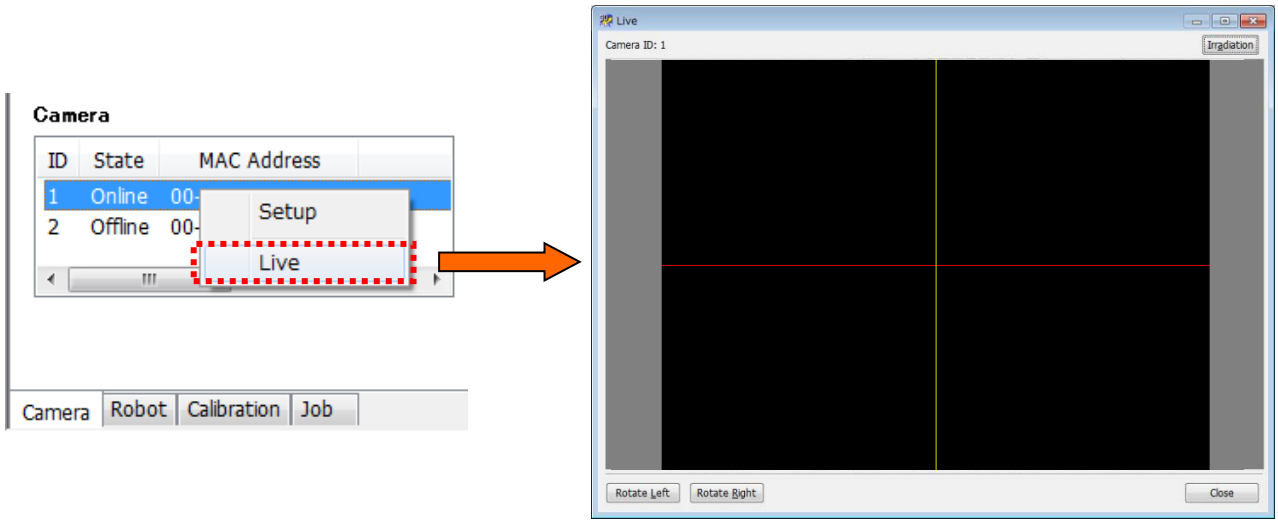


Fig. 7-24 Live image

7.9.3. Image monitor

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

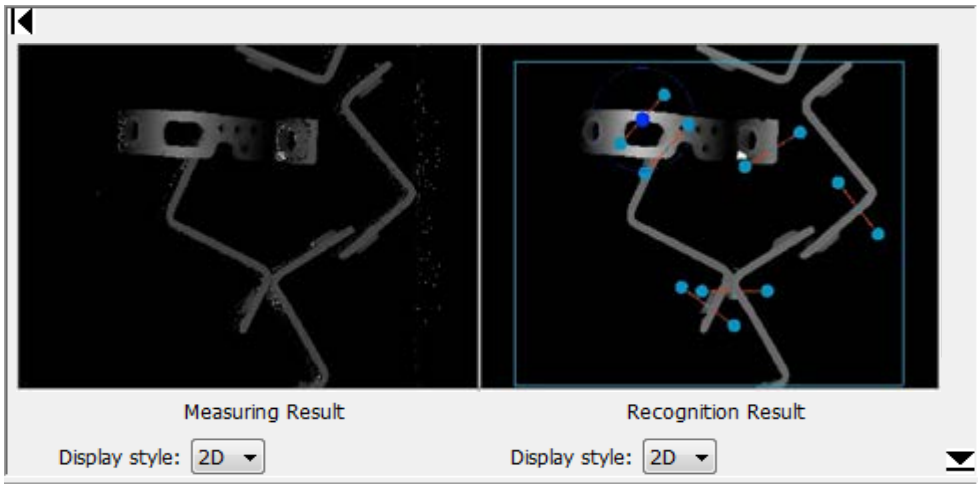


Fig. 7-25 Image monitor

The image center on 2D images displayed at the monitor is the XY origin of the camera coordinate system (see Fig. 3-14).

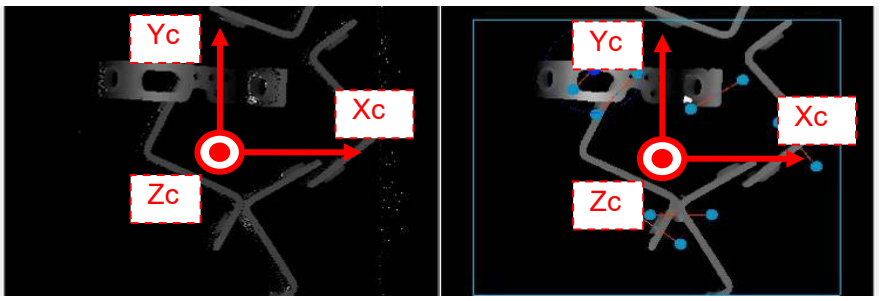


Fig. 7-26 Camera coordinate system in image monitor

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 7-5).

Table 7-5 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.

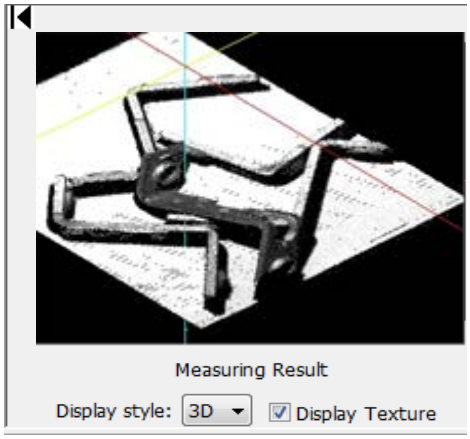


Fig. 7-27 Image monitor (3D display)

7.9.4. Setting/operation field

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

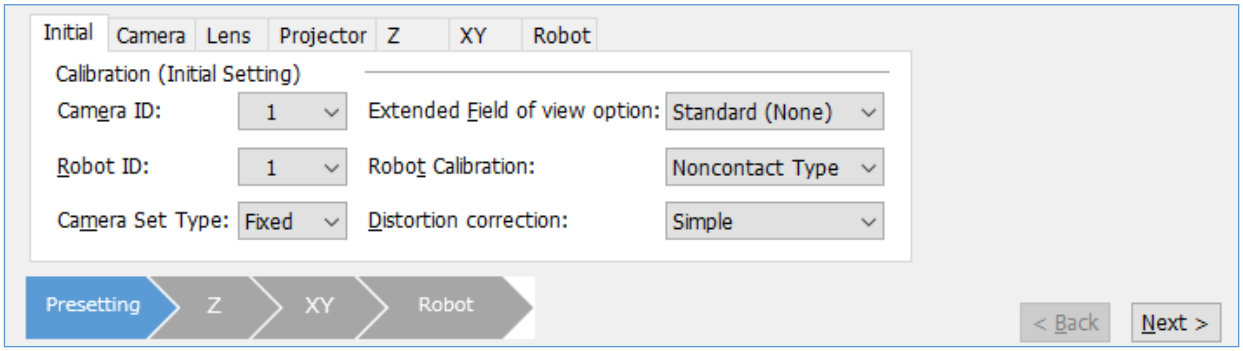


Fig. 7-28 Calibration setting/operation field

7.10. Connection Settings

7.10.1. 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.

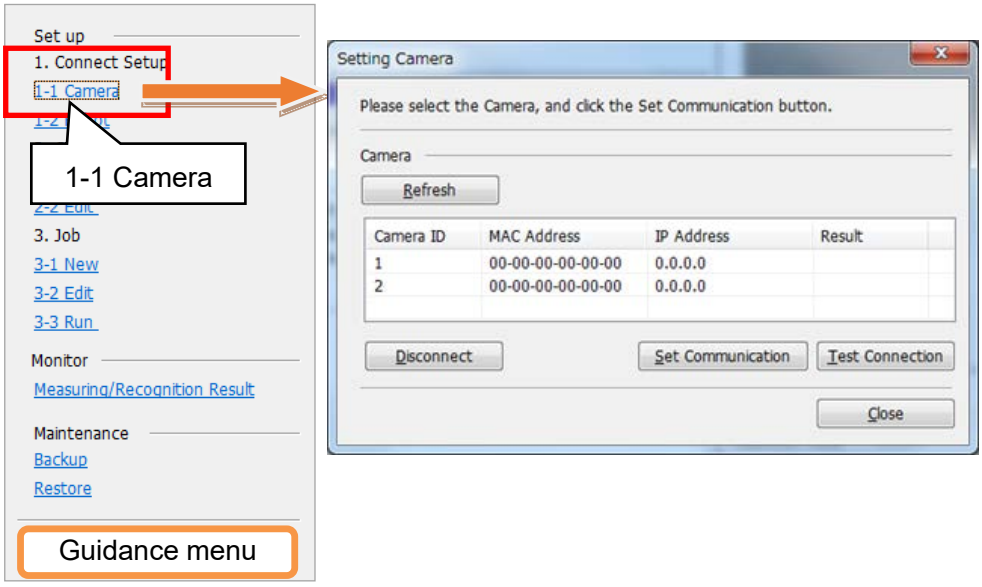


Fig. 7-29 Camera settings

Camera communication settings

Up to two cameras can be connected to a single edge computer. 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. The IP address should be different from the ones of other devices in the same network as the edge computer.By clicking the [Set] button, camera communication settings are written to the control unit.

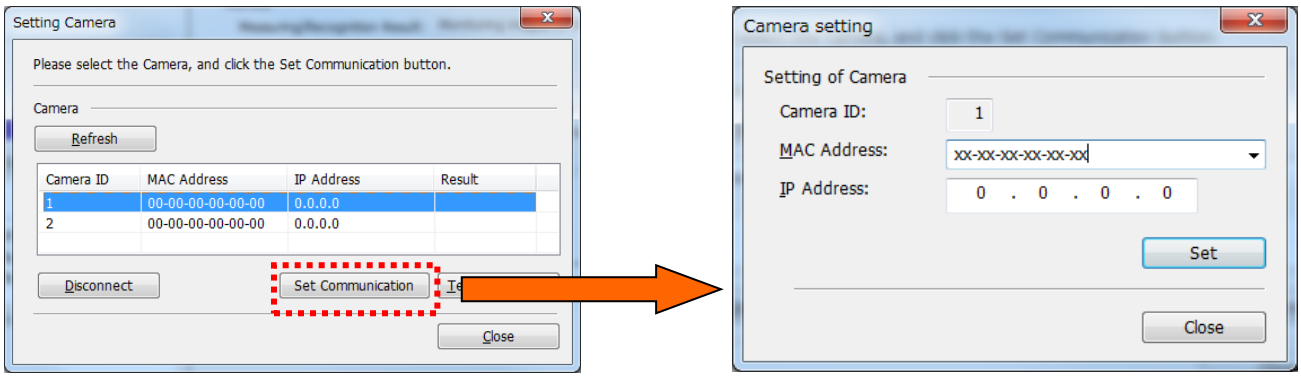


Fig. 7-30 Camera communication settings

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.

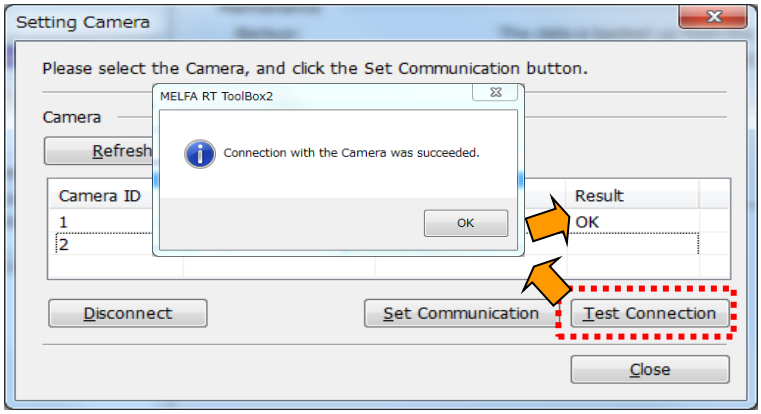


Fig. 7-31 Camera connection test

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.

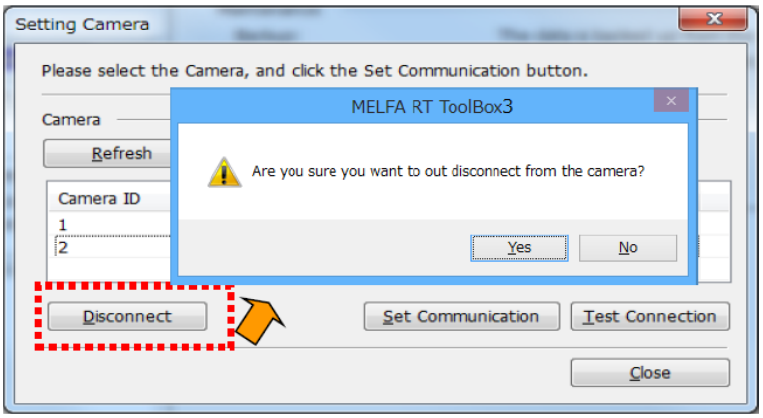


Fig. 7-32 Camera circuit disconnection

7.10.2. Robot settings

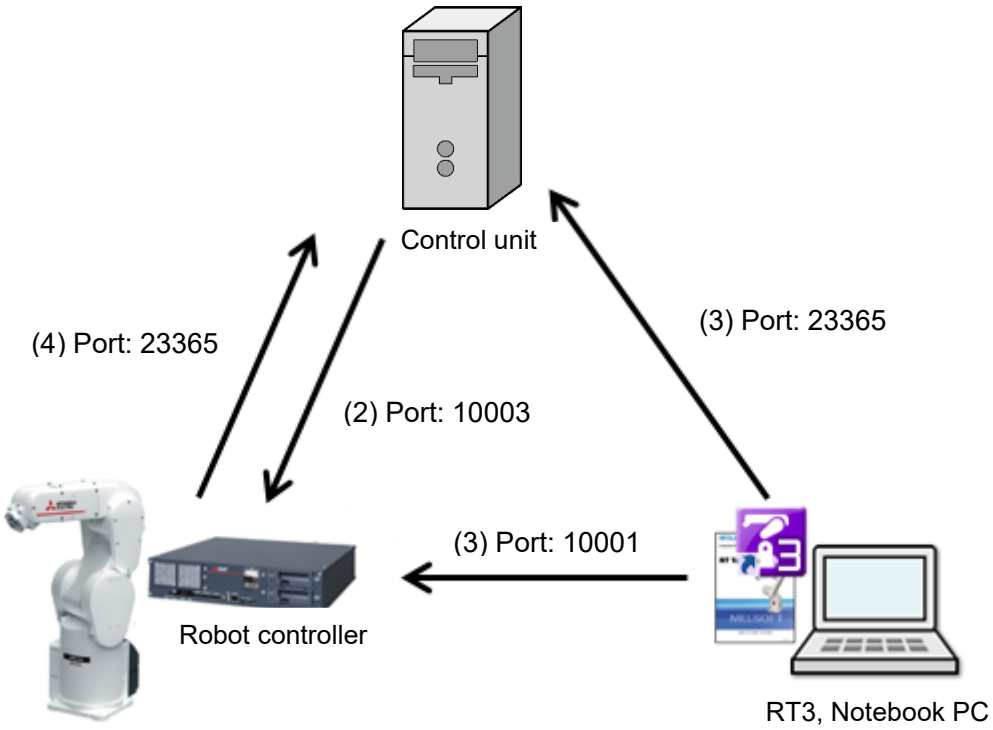


Fig. 7-33 Relationship diagram of port numbers

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

7.10.2.1. From robot to control unit

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.

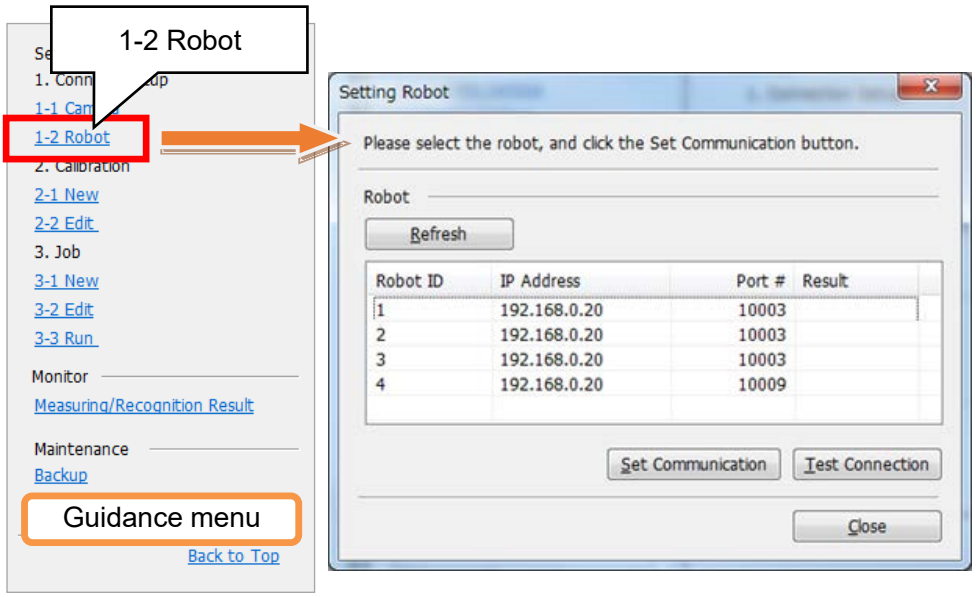


Fig. 7-34 Robot settings

Robot communication settings

Up to four robots can be connected to a single edge computer. 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. Click the [Set] button to write the robot communication settings to the edge computer.

◇◆◇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. 7-37)

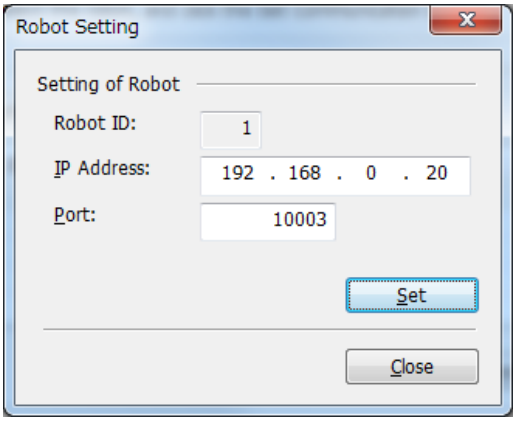


Fig. 7-35 Robot communication settings

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.

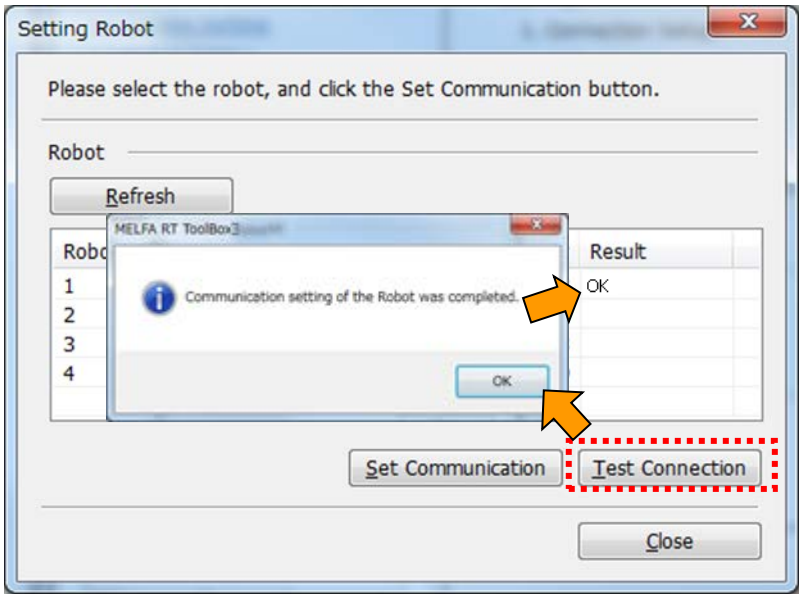


Fig. 7-36 Robot connection test

7.10.2.2. From robot to control unit

With the sample robot program contained in the CD-ROM (3F-52C-WIN) provided, "COM2:" is used for communication with the robot. If using with the COM port setting as is, specify settings as shown in Table 7-6.

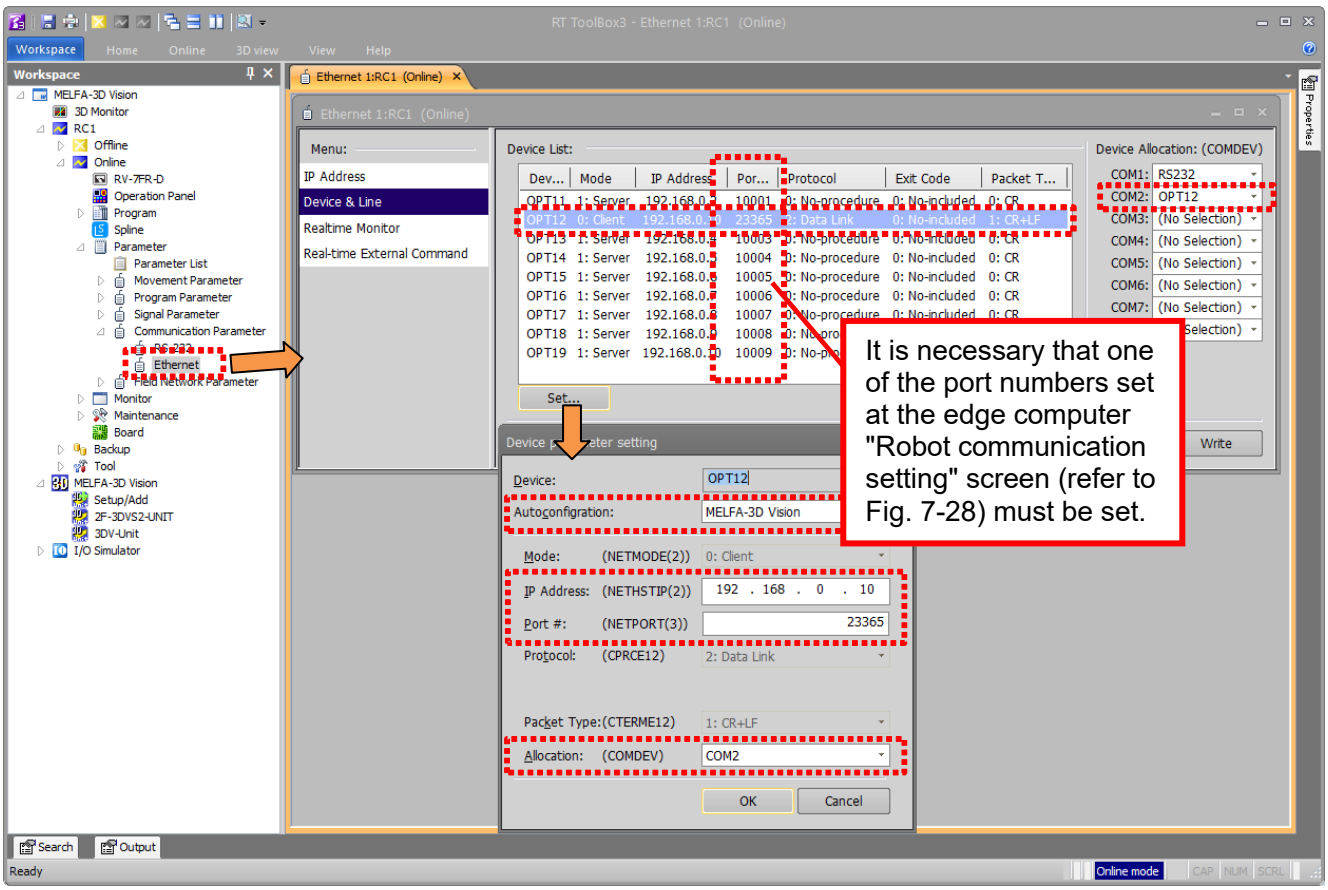


Fig. 7-37 Ethernet setting screen for robots

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 7-6 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. (refer to 7-8 Setting and Adding Control Units) as entered in the edge computer 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.

7.11. 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.

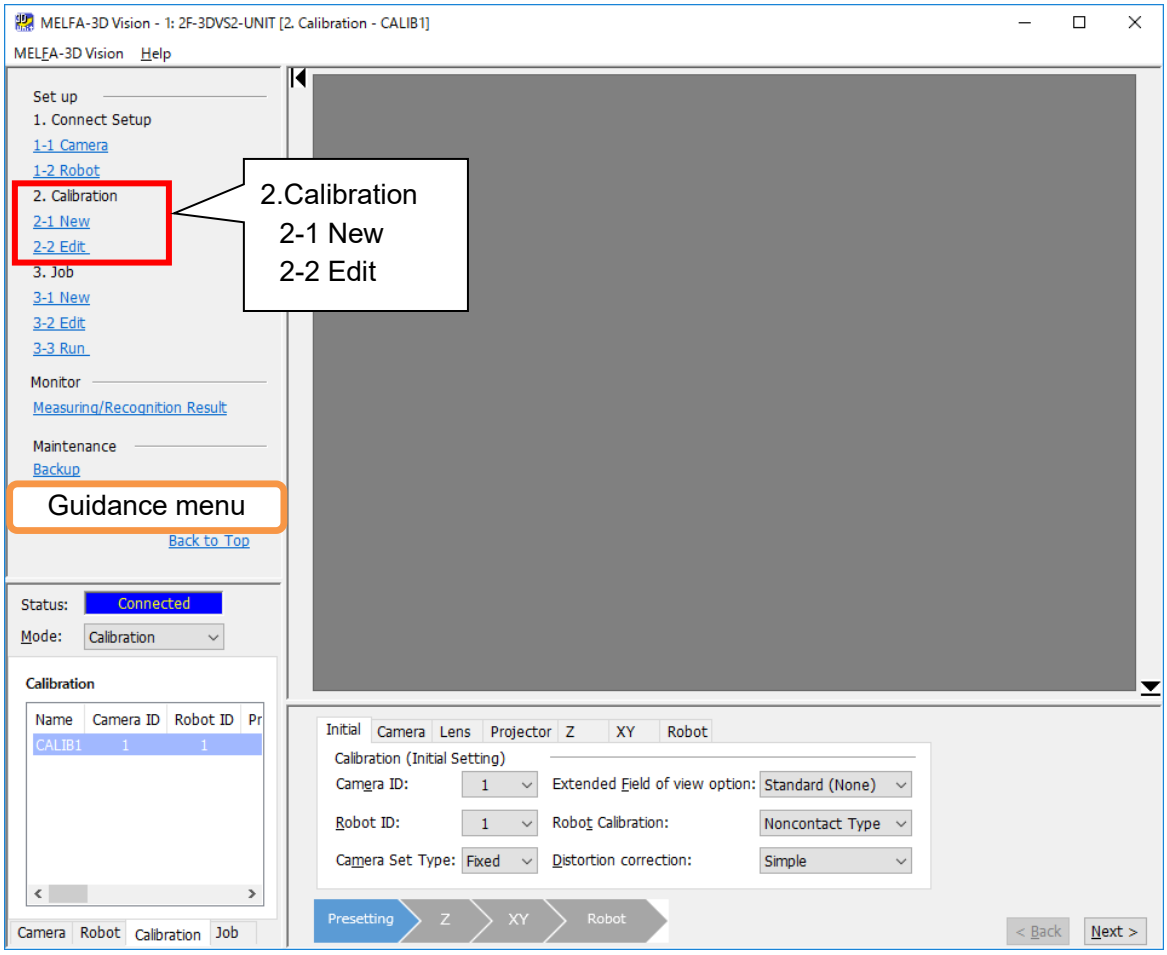


Fig. 7-38 Calibration

◇◆◇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.

7.11.1. Initial settings

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

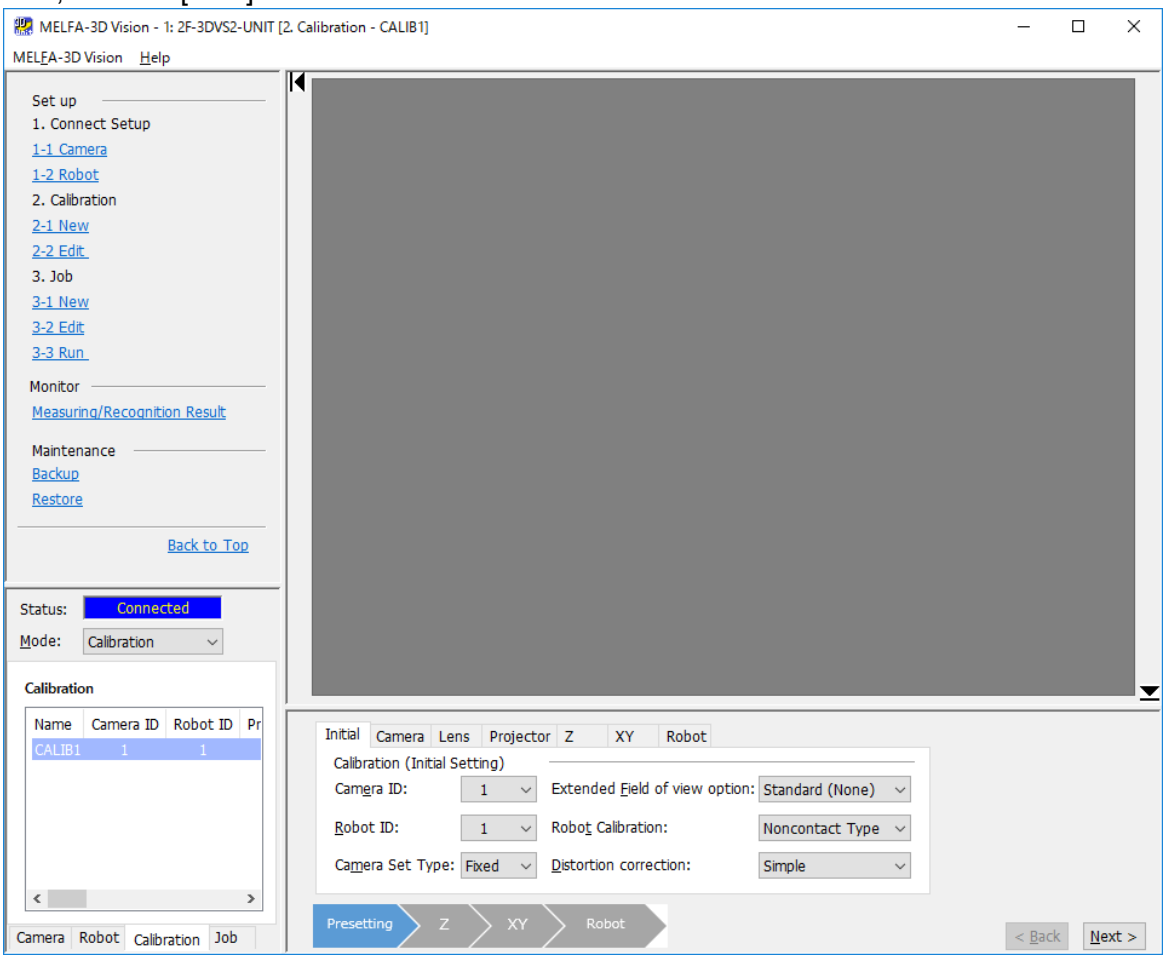


Fig. 7-39 Calibration (initial settings)

Table 7-7 Calibration (initial settings)

Item	Description
Camera ID	Camera ID being used (see 7.10.1)
Robot ID	Robot ID being used (see 7.10.2)
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.

7.11.2. Camera settings

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

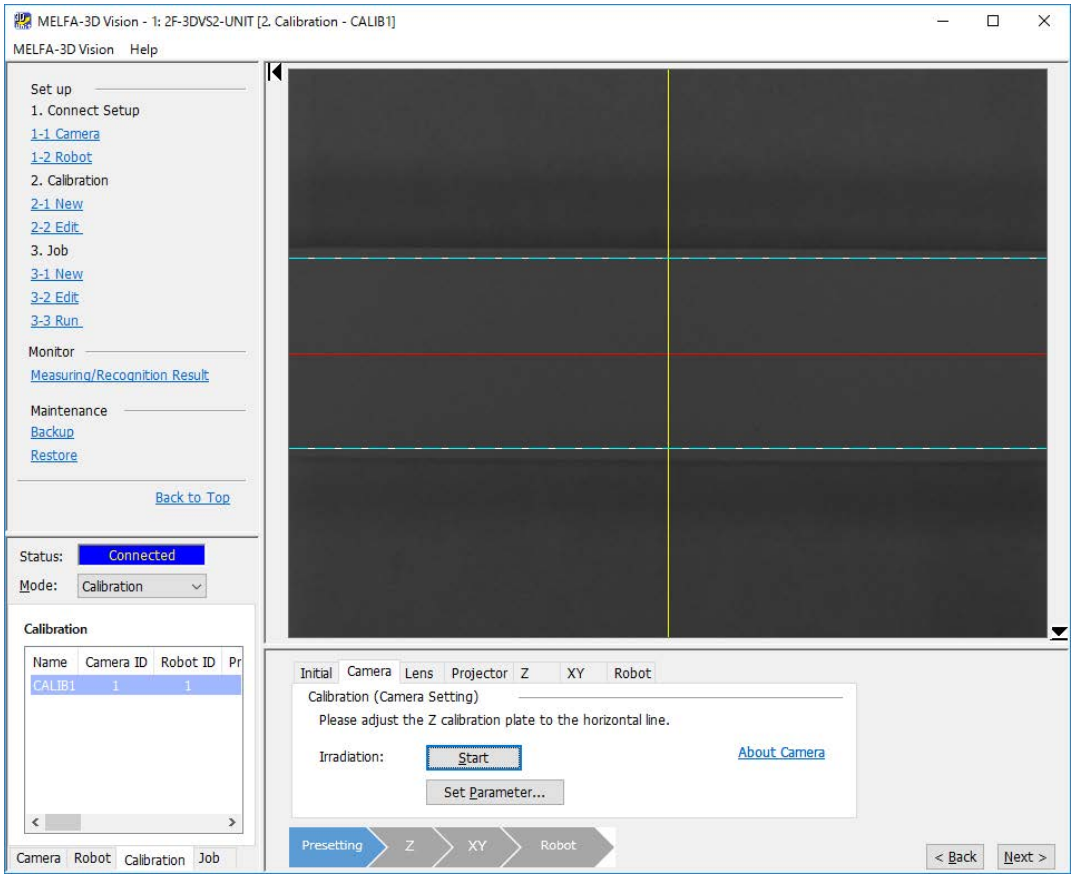


Fig. 7-40 Calibration (camera settings)

◇◆◇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.

Irradiation range adjustment

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.

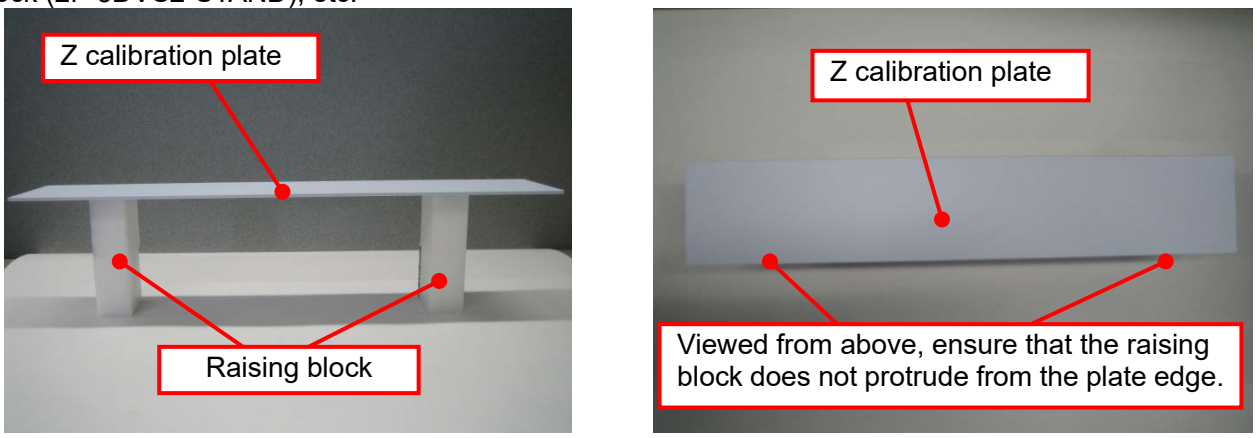


Fig. 7-41 Example of raised Z calibration plate

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.

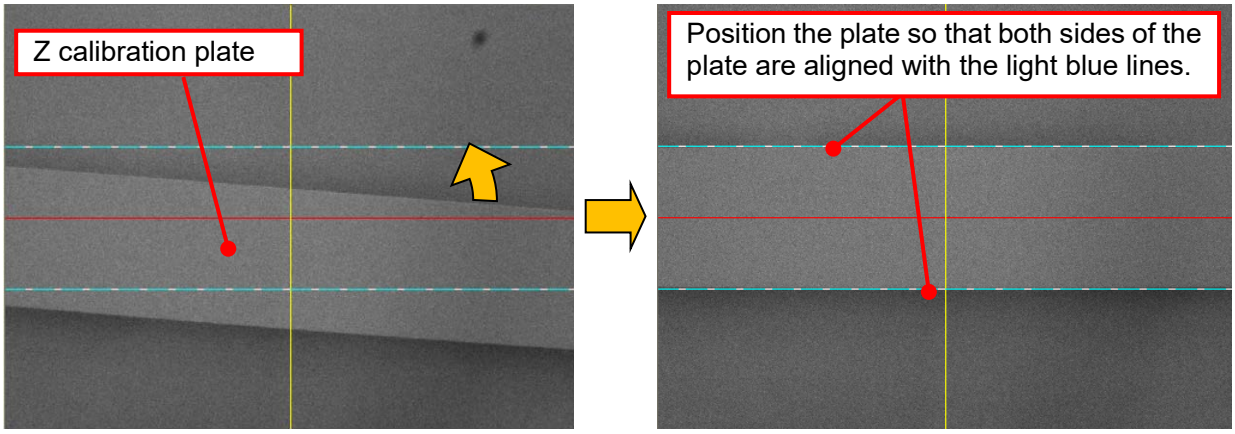
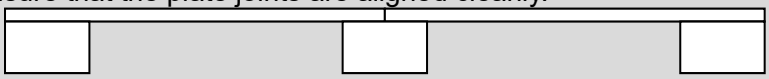


Fig. 7-42 Example of Z calibration plate alignment

◇◆◇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. 7-43 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.

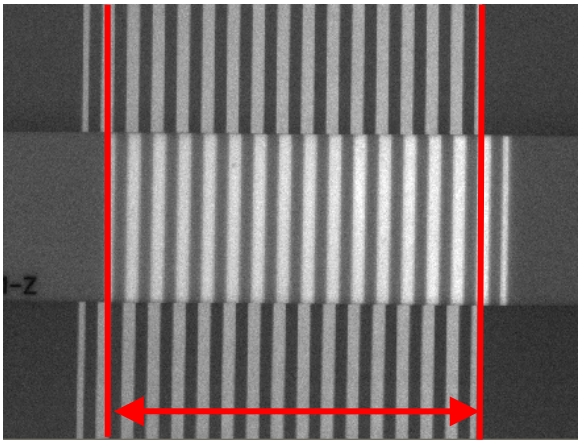


Fig. 7-43 Measurable area

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

7.11.2.1. 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 7.12.2 is not satisfactory, measurement results can be improved by changing the camera parameters.

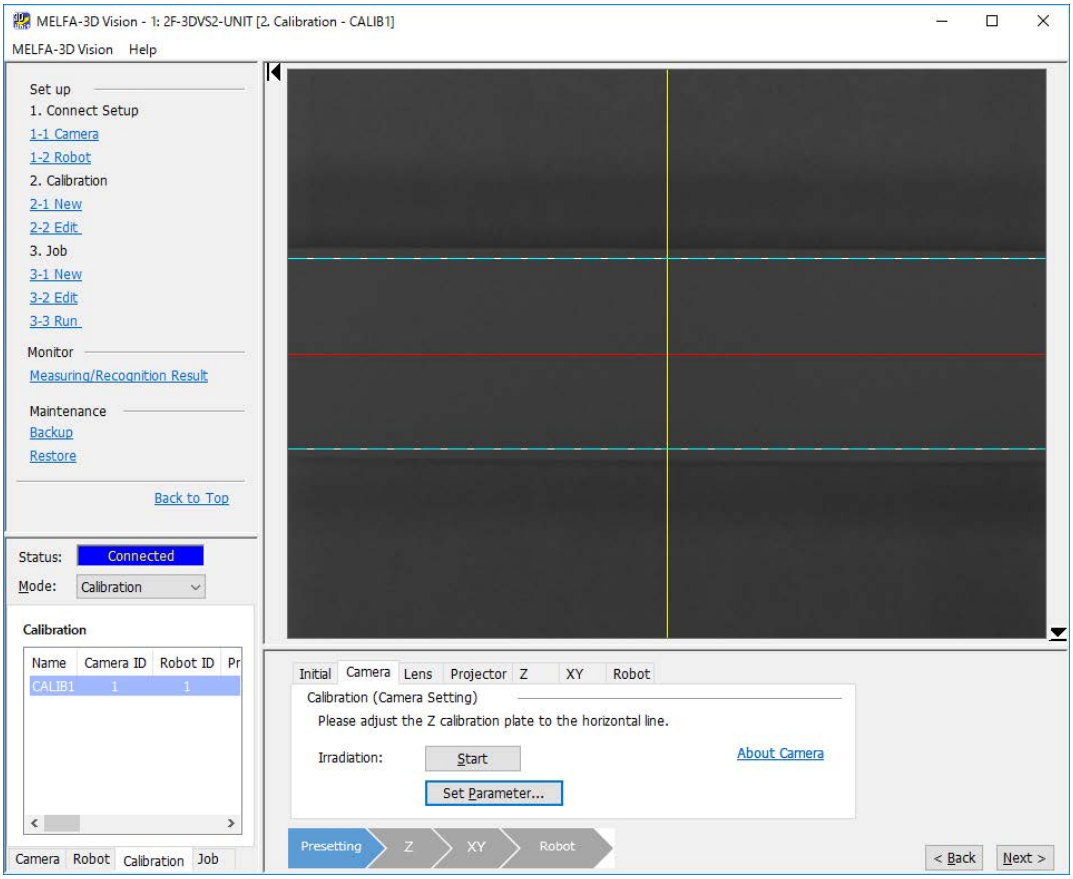


Fig. 7-44 Calibration (camera settings - parameter settings)

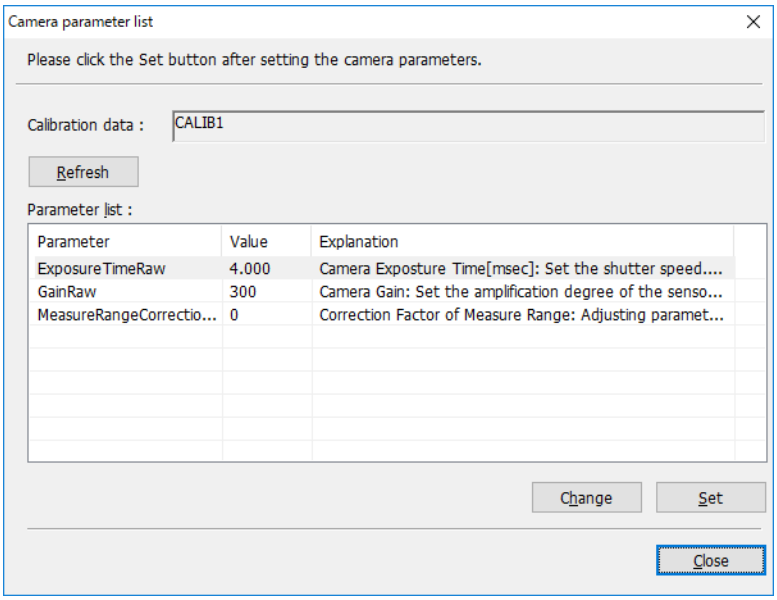


Fig. 7-45 Camera parameter list

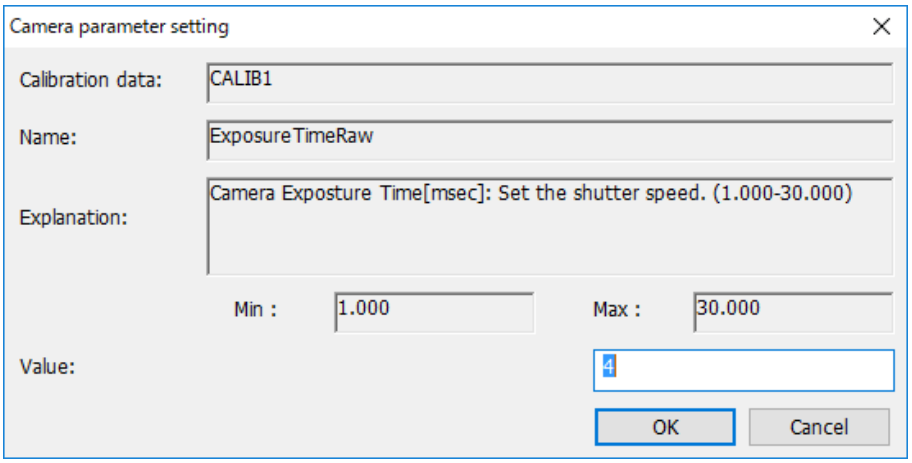


Fig. 7-46 Camera parameter settings

Table 7-8: Camera parameter list

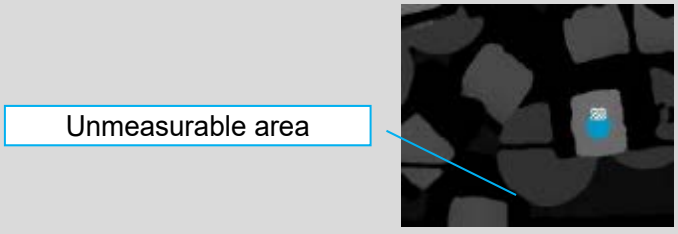
Parameter name	Unit	Description	Range	Default setting
ExposureTimeRaw	msec	Camera exposure time [msec]: Set the shutter speed.	1.000 to 30.000	4.000
GainRaw	-	Camera gain: Set the amplification degree of the sensor signal (Sensitivity).	300 to 850	300
MeasureRange CorrectionFactor	-	Correction Factor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

◇◆◇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.

◇◆◇ Camera gain ◇◆◇
When a larger gain value is input, the image becomes brighter, which increases the noise in proportion to the value.

◇◆◇ 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.



7.11.3. Lens settings

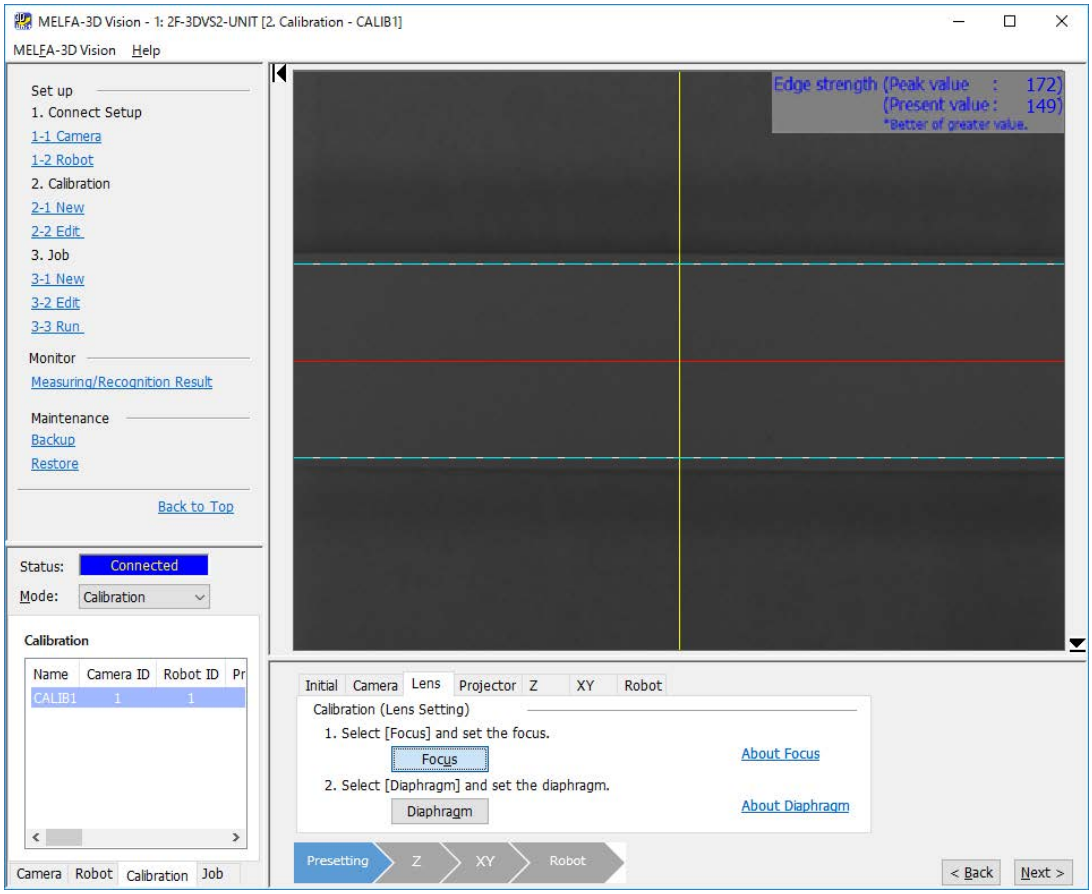


Fig. 7-47 Calibration (lens settings - focus)

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.

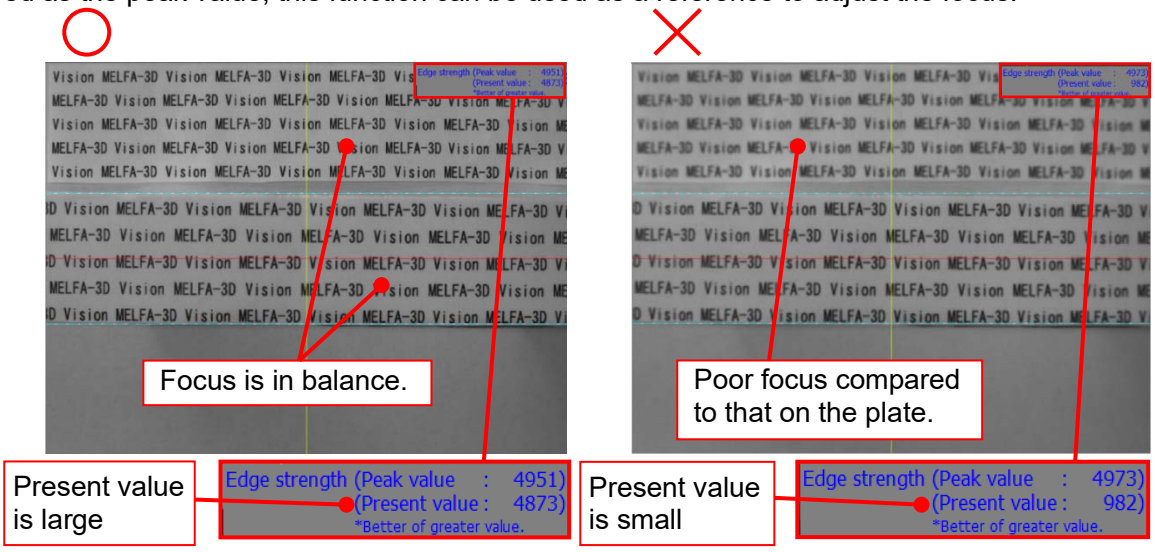


Fig. 7-48 Temporary camera focus adjustment example

Temporary aperture adjustment

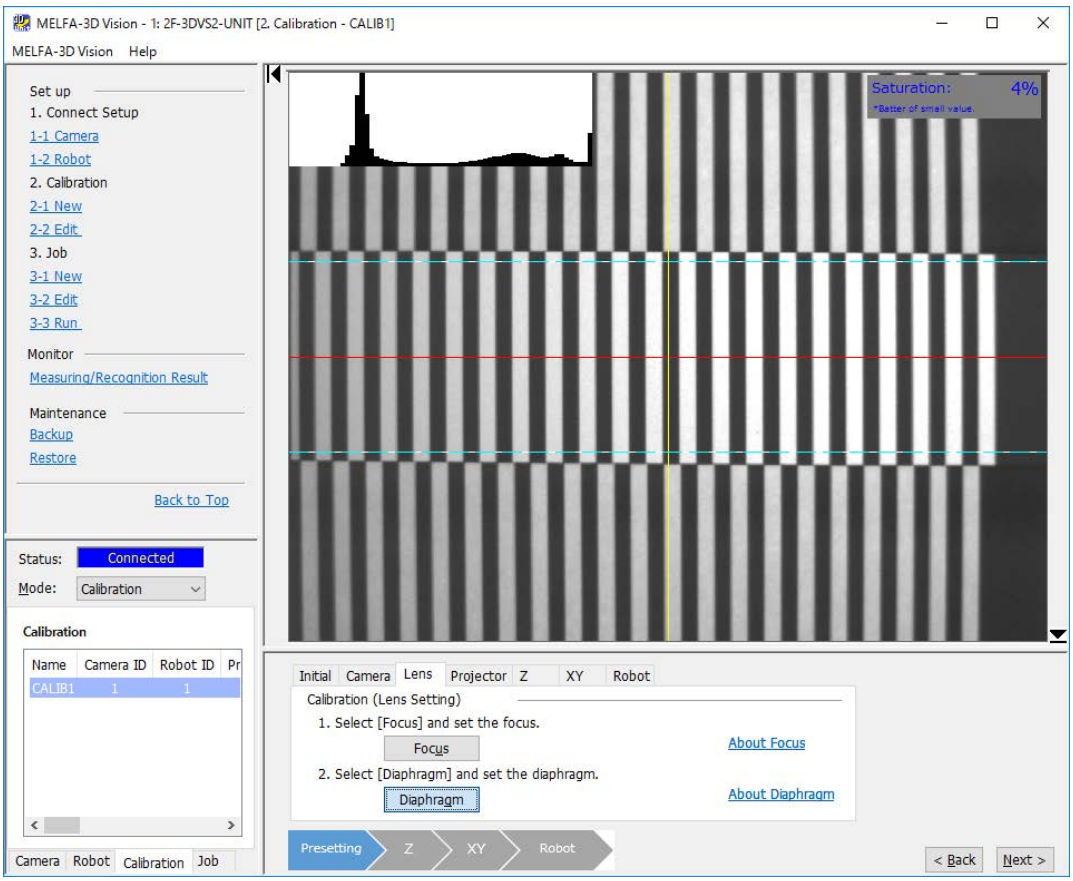


Fig. 7-49 Calibration (lens settings - diaphragm)

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%.

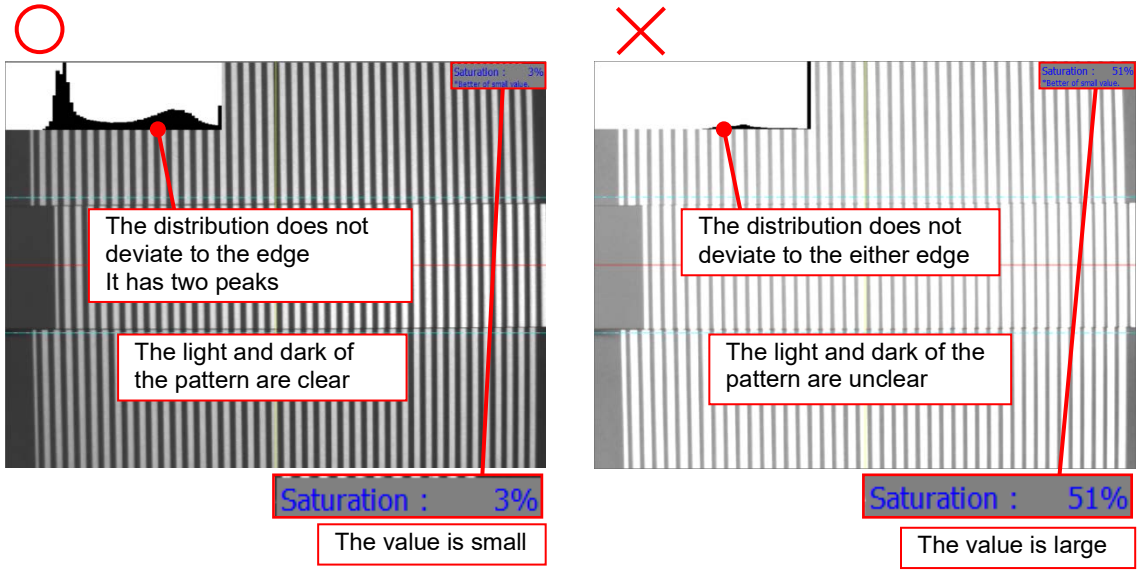


Fig. 7-50 Temporary adjustment example for the camera diaphragm

7.11.4. Projector settings

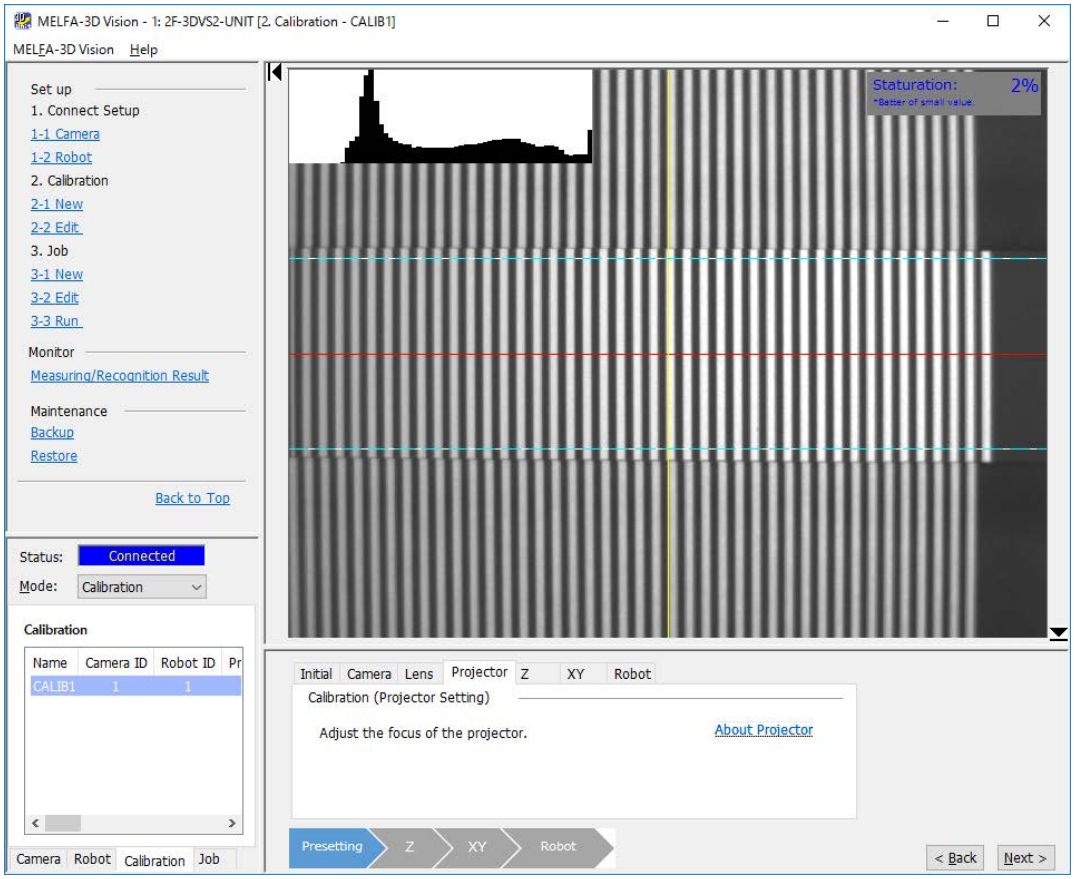


Fig. 7-51 Calibration (projector settings)

Temporary focus adjustment

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. 7-53), 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).

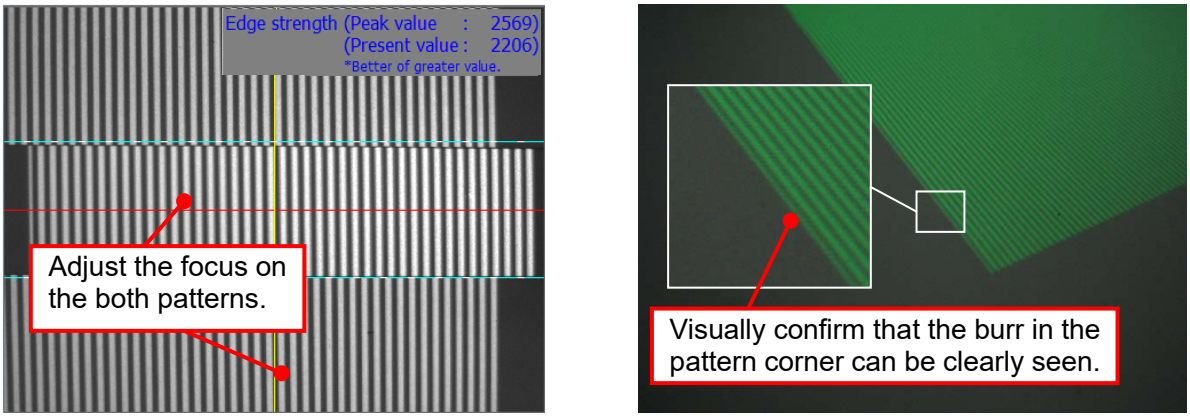


Fig. 7-52 Temporary projector focus adjustment

Upon completing the focus adjustment, turn the focus fixing screw (refer to Fig. 7-53) and fix the focus of the projector. Note 1

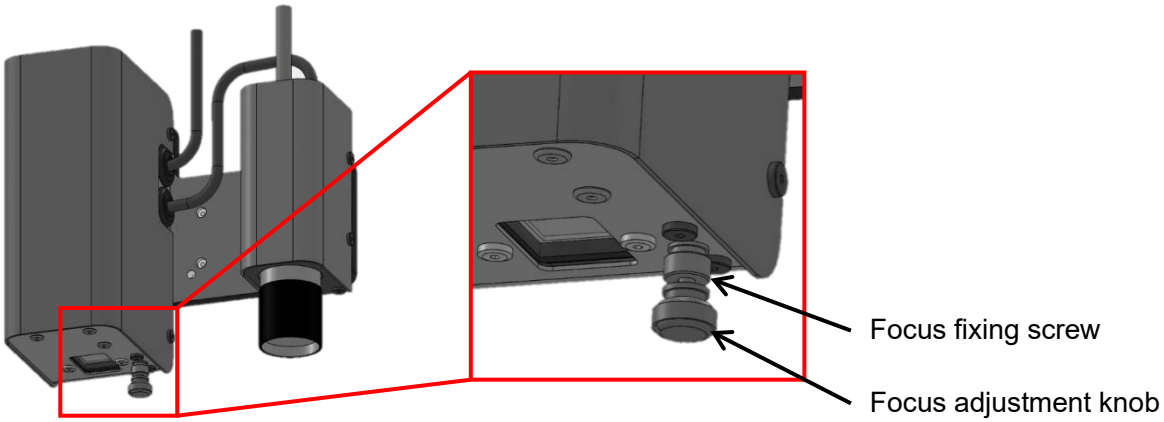


Fig. 7-53 Focus adjustment knob and focus fixing screw

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

7.11.5. 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 stored in "Doc\ENG\3DVS-Calibration_Marker_ENG\Checkerboard_8x11.pdf". In addition, use it by scaling depending on the usage environment (camera viewing field size).

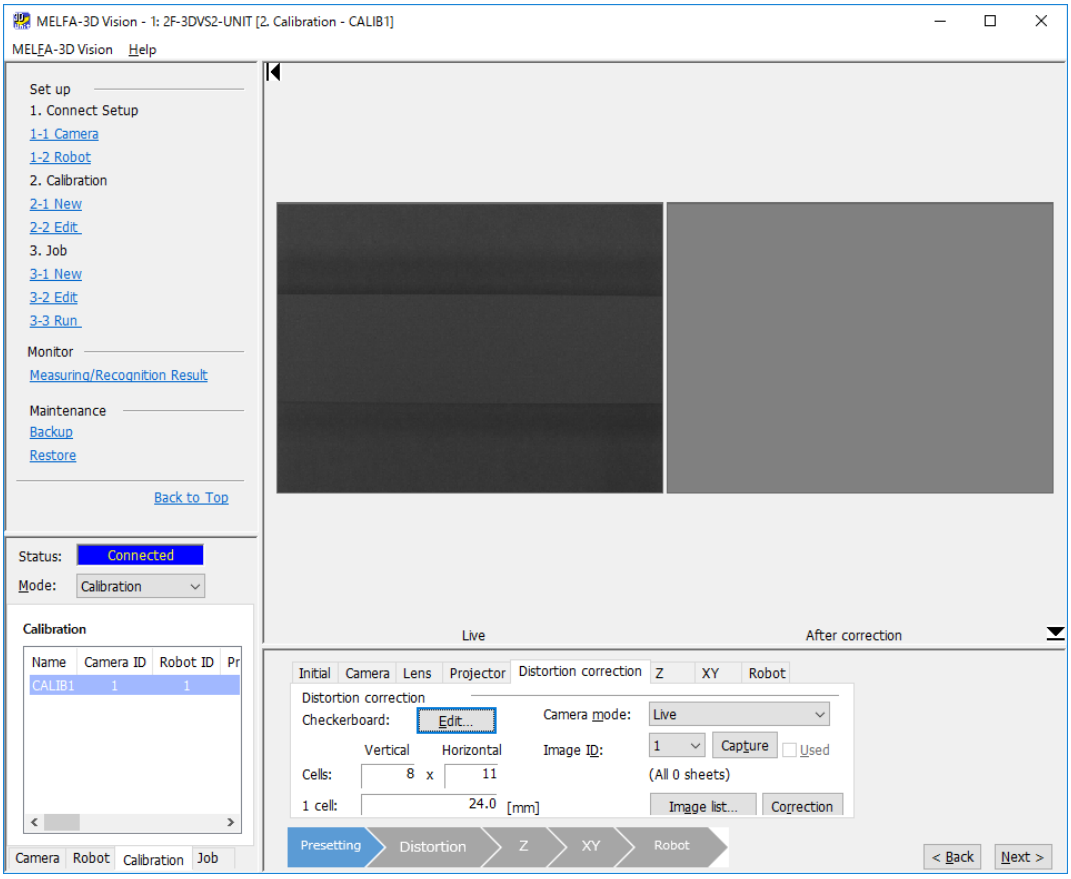


Fig. 7-54 Calibration (distortion correction)

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.

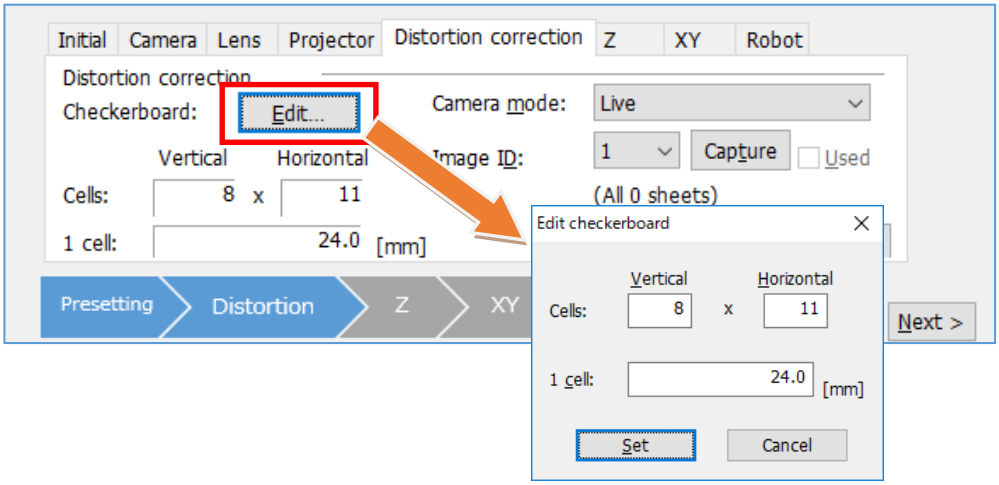


Fig. 7-55 Checkerboard settings

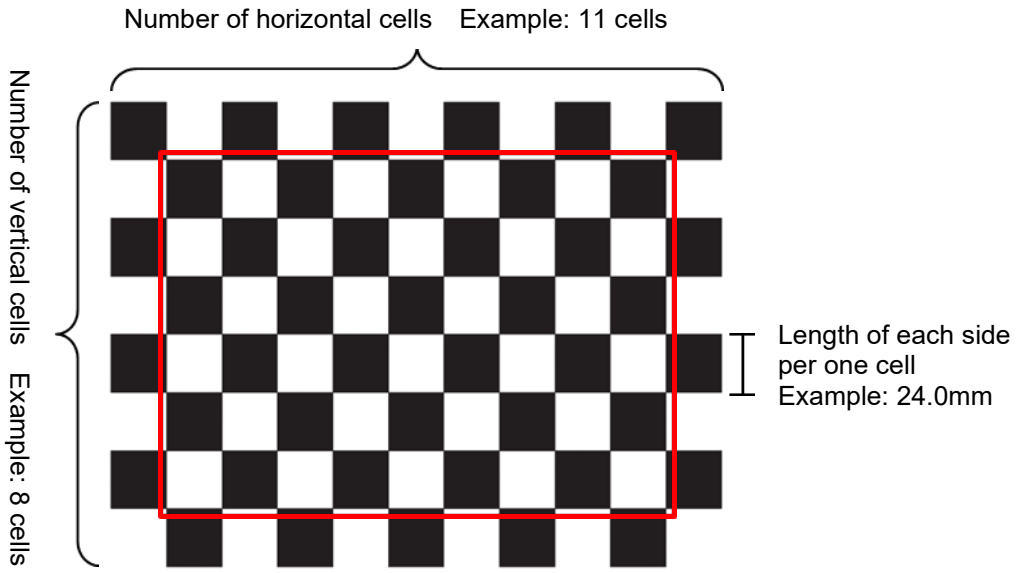


Fig. 7-56 Instructions for the parameters during setting of the checkerboard

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.

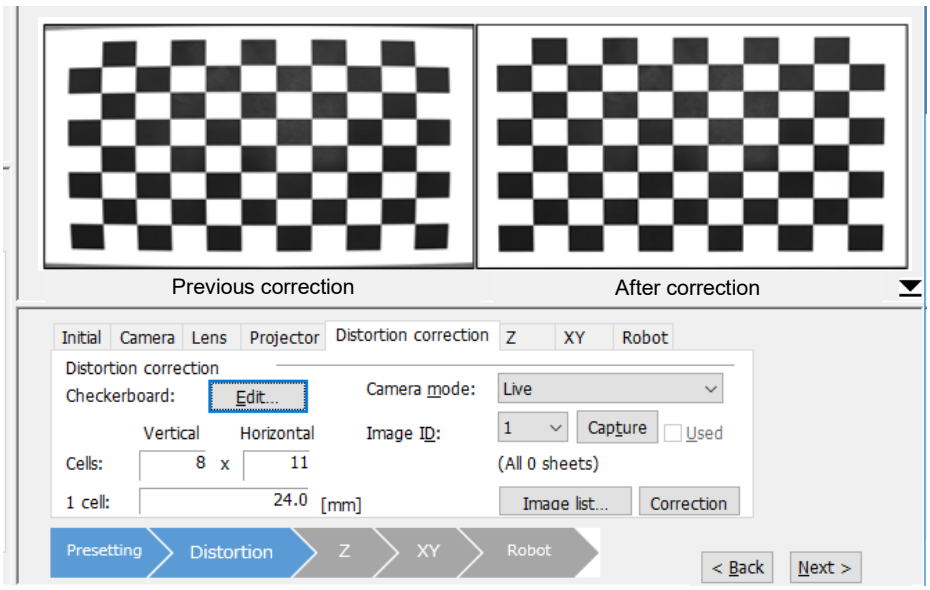


Fig. 7-57 Method of photographing images

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.

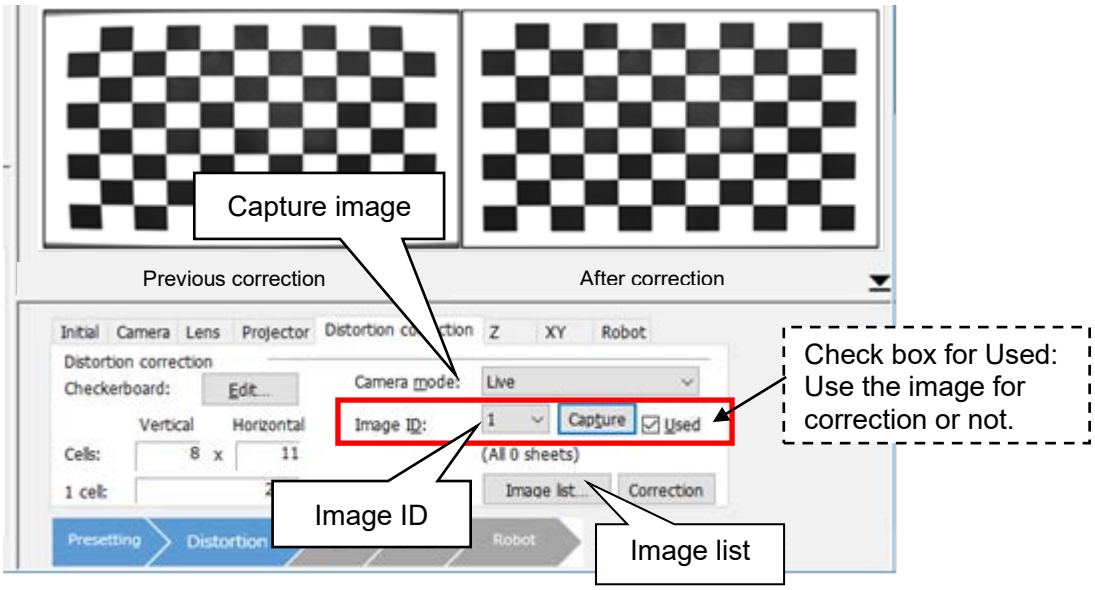


Fig. 7-58 Confirmation of the capture images and the selection method of images to use for distorted correction

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.

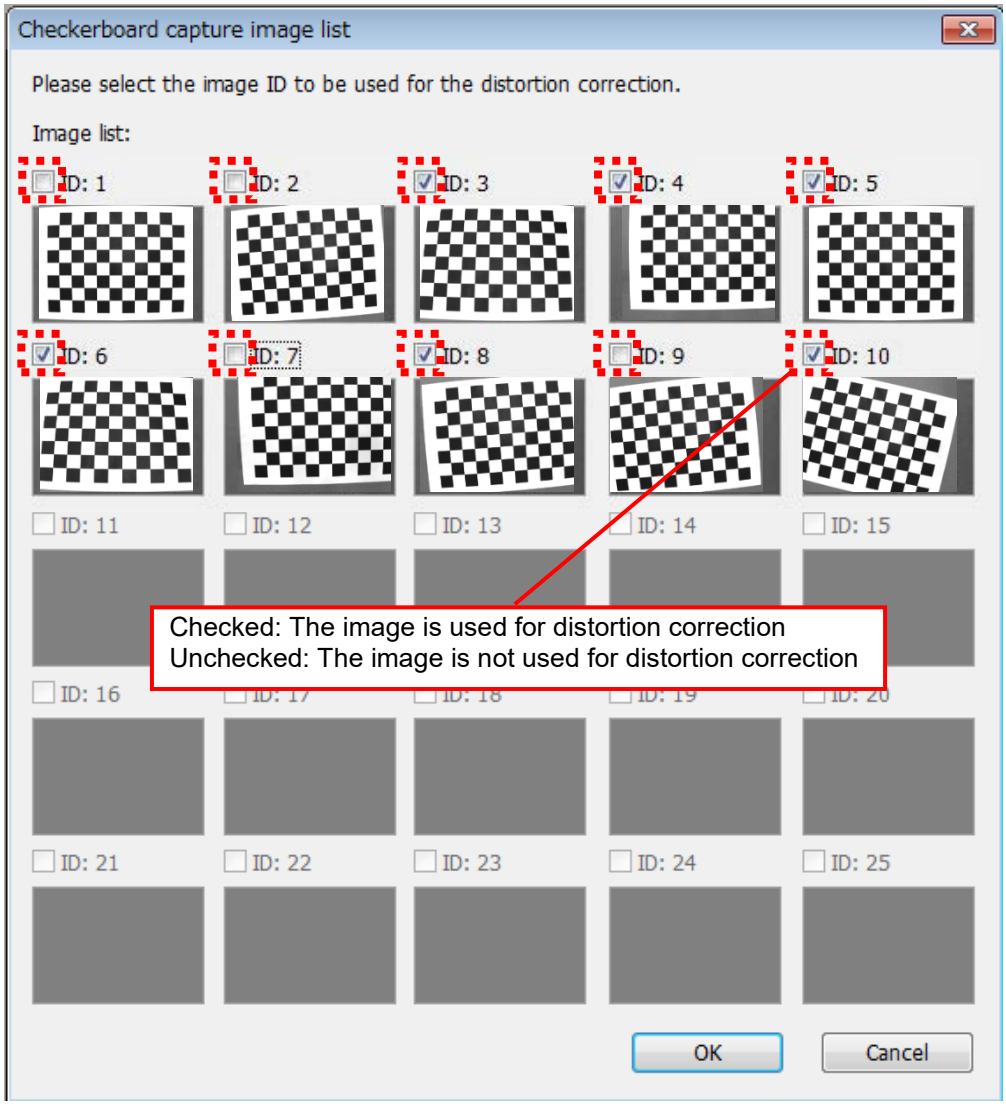


Fig. 7-59 Image list

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.

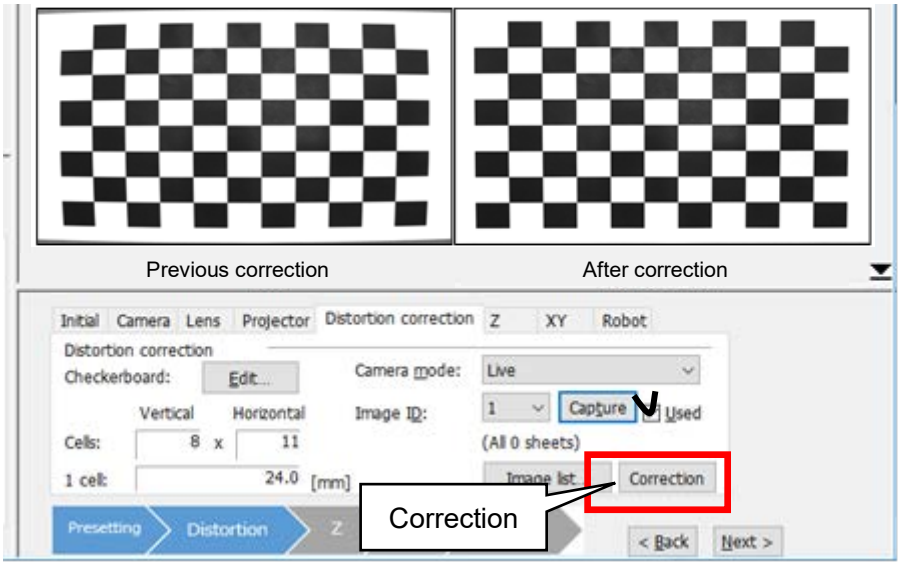


Fig. 7-60 Implementation method of distortion correction

◇◆◇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].

7.11.6. 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.

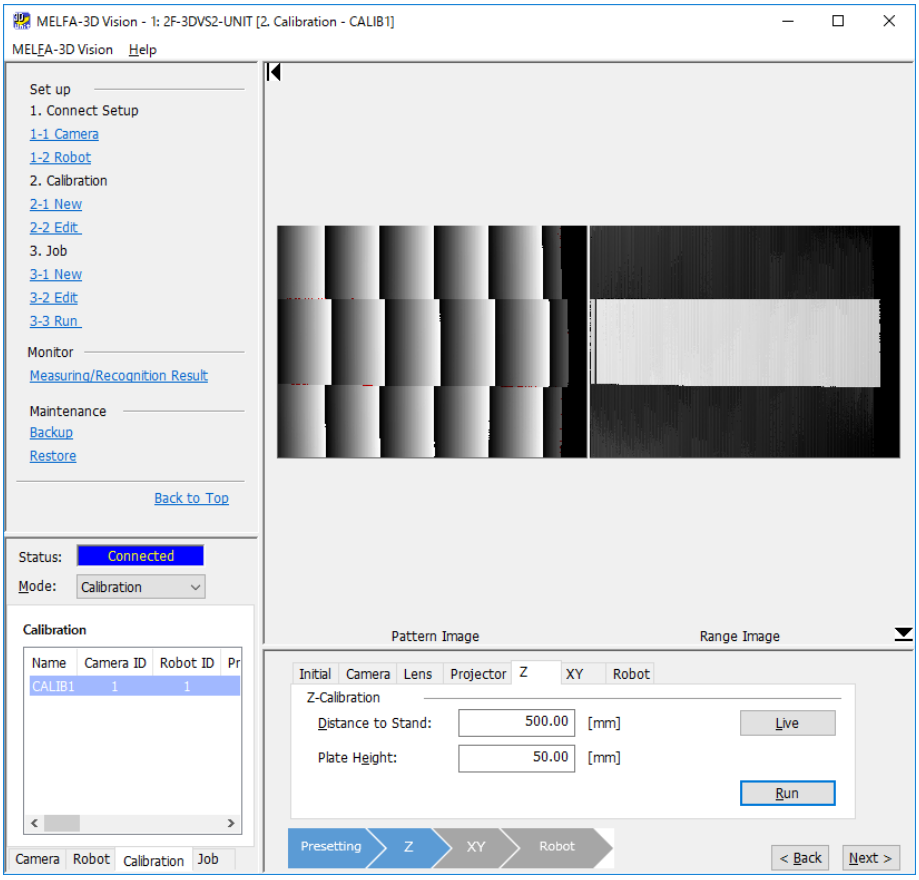


Fig. 7-61 calibration (Z calibration)

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

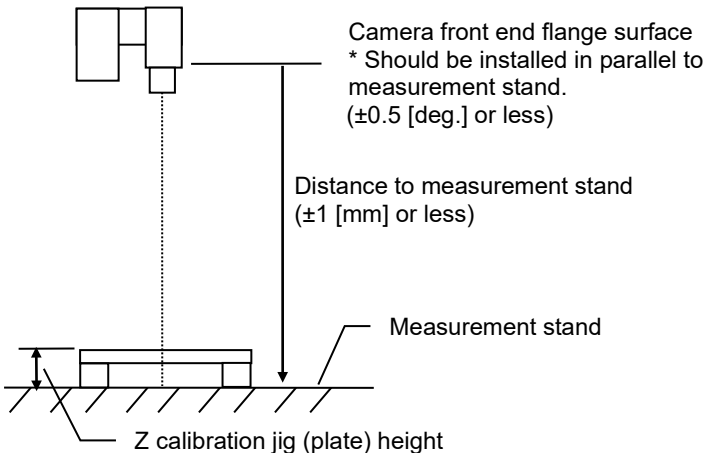


Fig. 7-62 Z calibration parameter description

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. 3-14.

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.

Performing Z calibration

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.

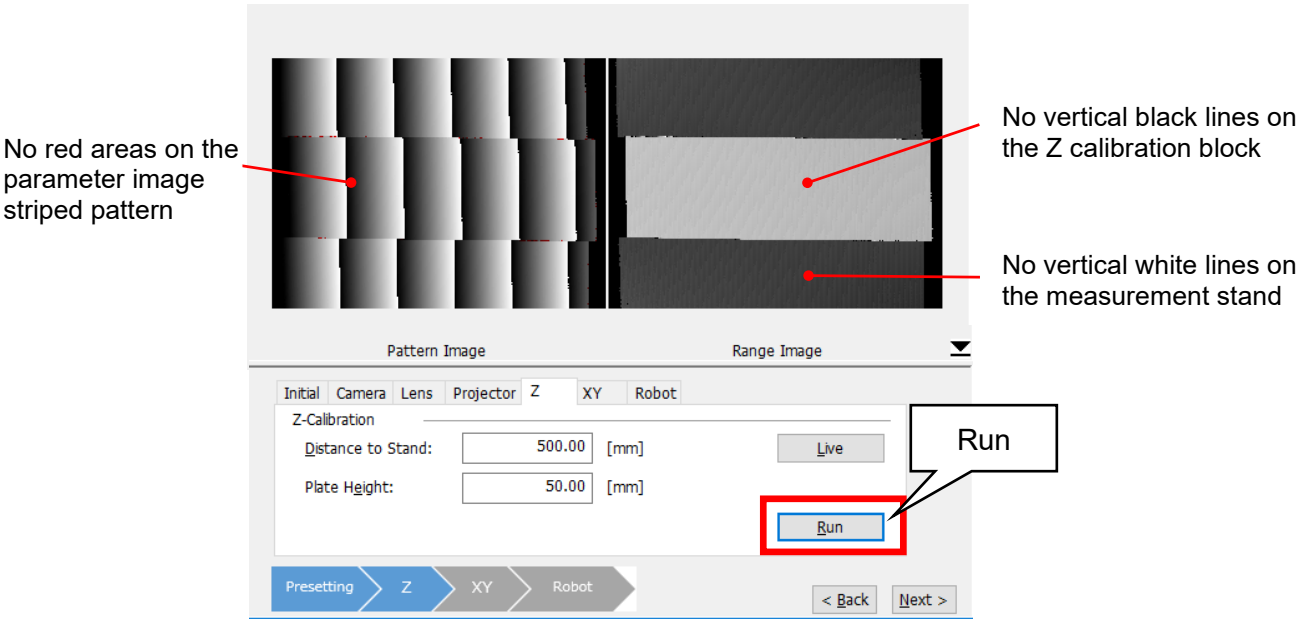


Fig. 7-63 Successful example of Z calibration

Check the following if the displayed image is not as shown in Fig. 7-63.

Table 7-9: 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 "7.11.3 Lens settings" or "7.11.4 Projector settings" 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?	If so, return to "7.11.3 Lens settings" or "7.11.4 Projector settings" 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.

7.11.7. 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.

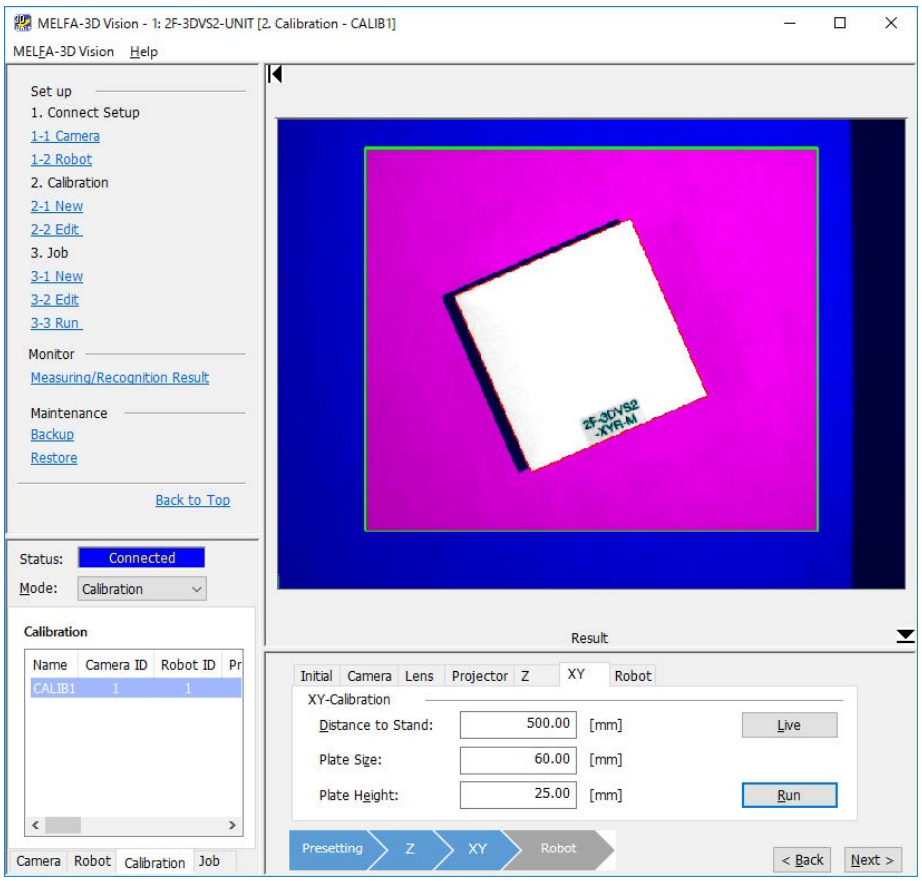


Fig. 7-64 calibration (XY calibration)

◇◆◇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.

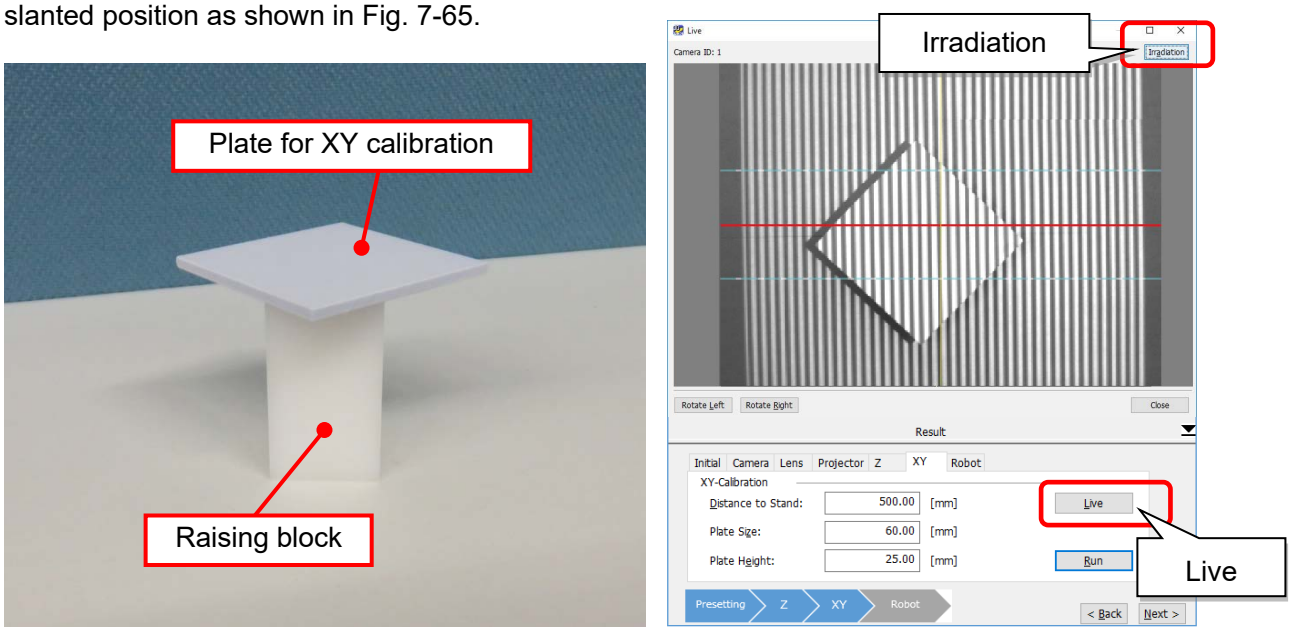
Entering the size and height of plate

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.

Positioning the XY calibration plate in the camera head measurable range

Click the [Live] button to open the live image screen, then click the [irradiation] button, and locate a plate for XY Calibration within the pattern irradiation area. When doing so, place the square XY calibration plate in a slanted position as shown in Fig. 7-65.



Example of piling up the plate

Display screen for RT ToolBox3

Fig. 7-65 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. 7-66Fig. .

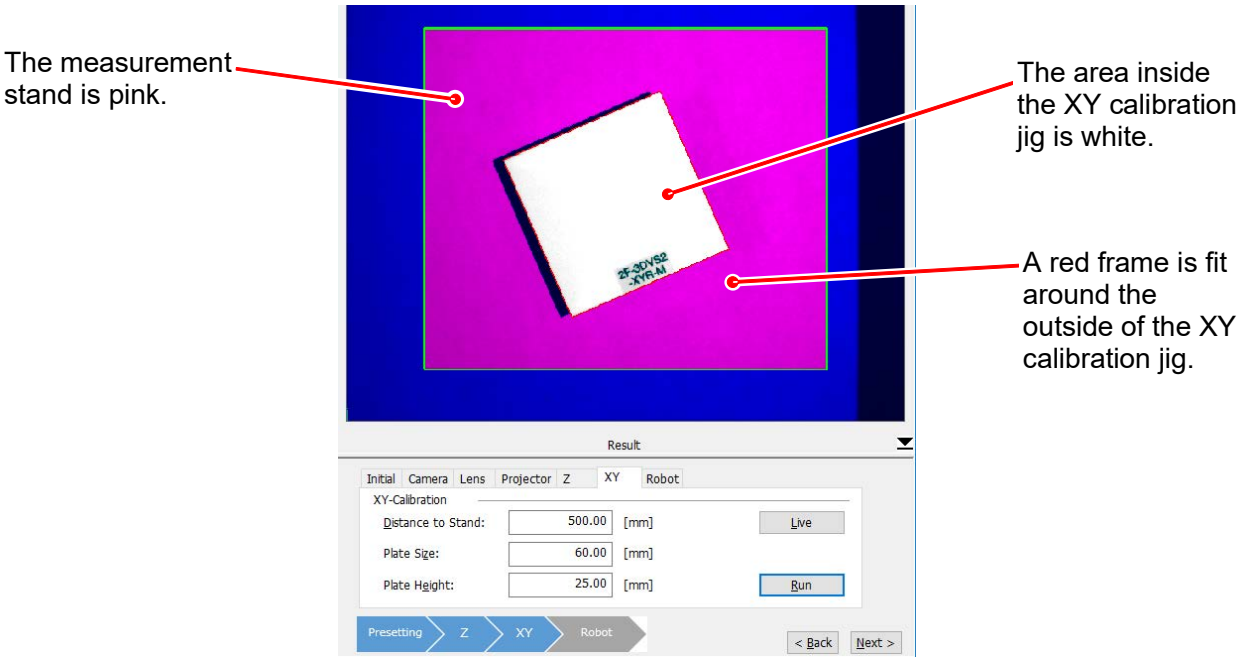


Fig. 7-66 Successful example of XY Calibration

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.

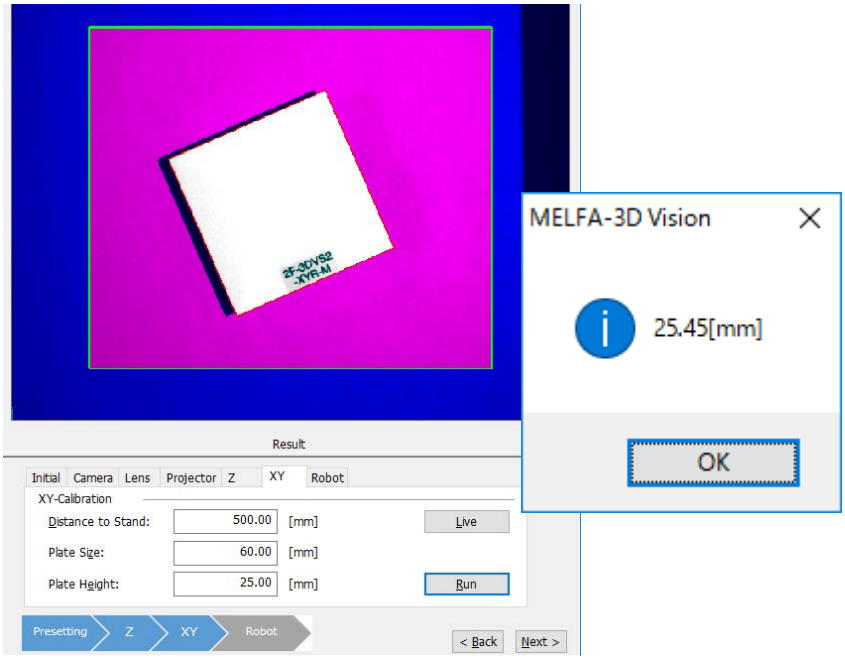


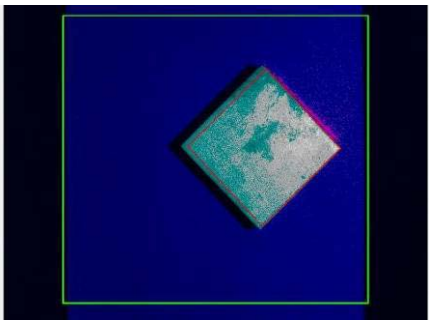
Fig. 7-67 Accuracy validation for calibration Z (display of the average Z value)

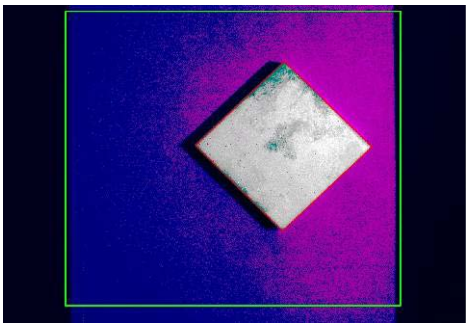
Check the following if the displayed image is not as shown in Fig. 7-66.

Table 7-10: Check items when XY calibration unsuccessful

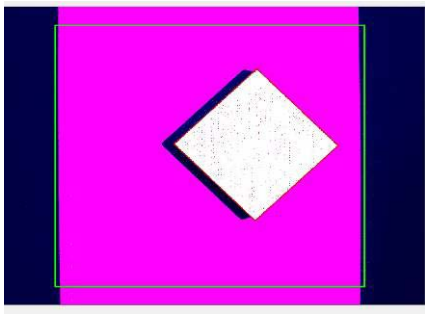
No.	Check item	Remedy
1	Are the values entered for the distance to the measurement stand, the plate size, and the plate height correct?	Ensure that the actual values are the same as the entered values.
2	Is there any ambient light Note 1?	Block any ambient light.
3	Is the glossy surface of the XY calibration 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.

7.11.8. 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.

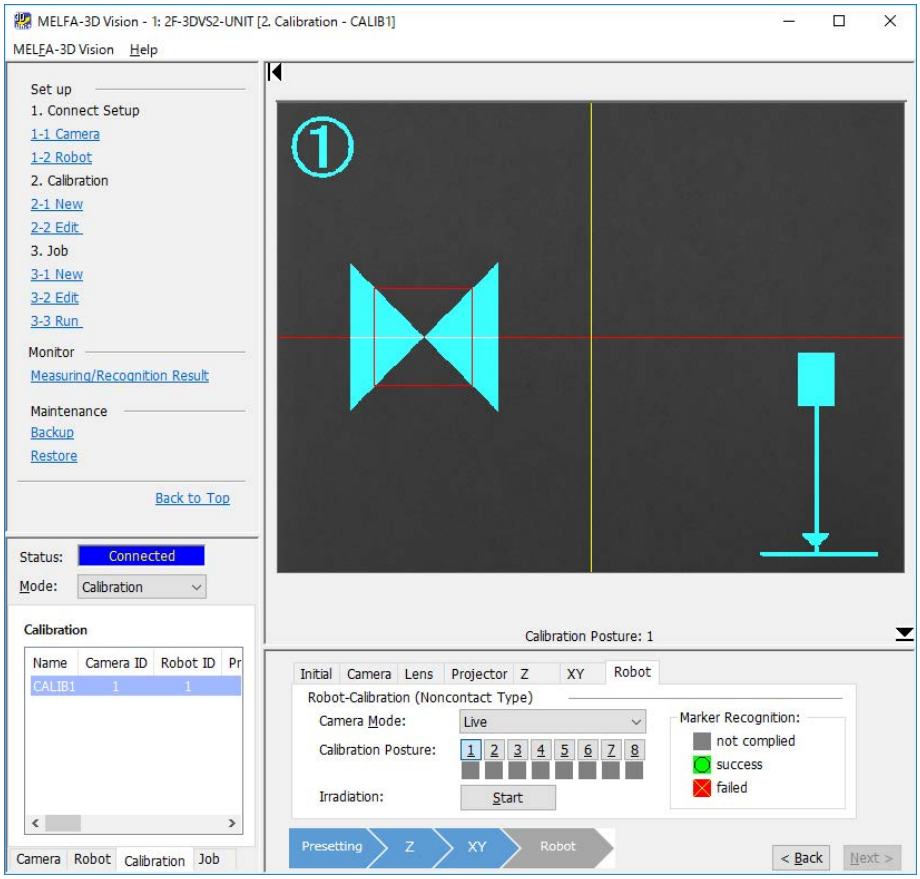


Fig. 7-68 calibration（Robot calibration）

Table 7-11: 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 11.4) Note 1 can be used.
Please note that robot calibration uses the robot calibration program (JRCA.prg) (see 11.3) 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 11.5 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.

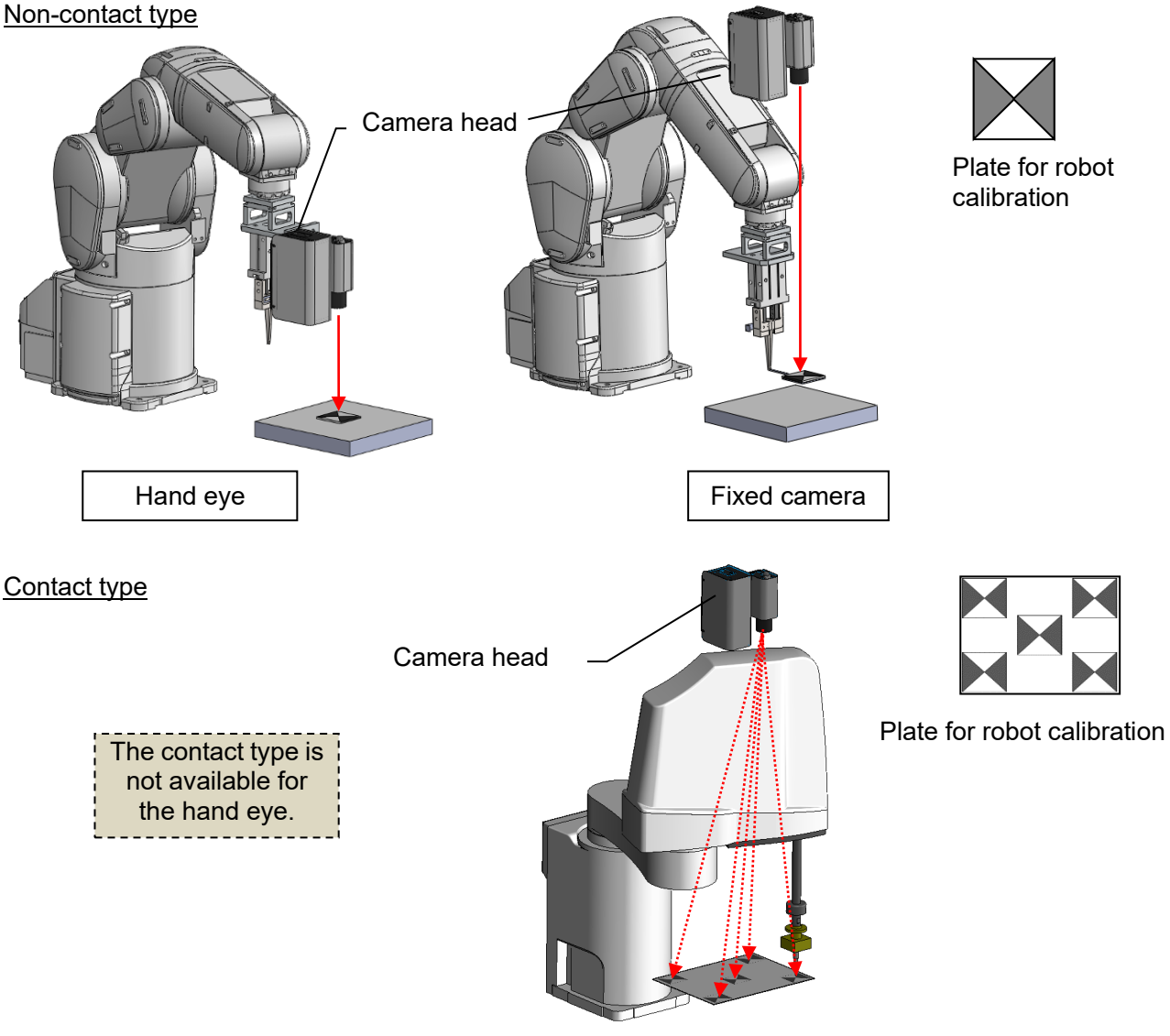


Fig. 7-69 Hand eye and fixed camera

Note 1: A calibration plate / sheet is stored in "Doc\ENG\3DVS-Calibration_Marker_ENG\Targetmarker.pdf" in the CD-ROM.

7.11.8.1. 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.

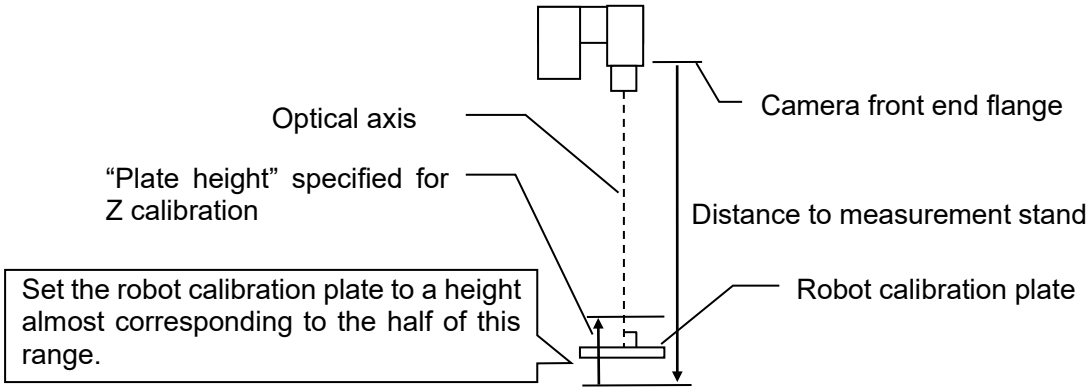


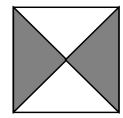
Fig. 7-70 Distance to robot calibration plate

Set the camera mode to the live image, and then select (1) from the calibration postures (see Fig. 7-71). 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 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.

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. 7-71). 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.



For robot calibration

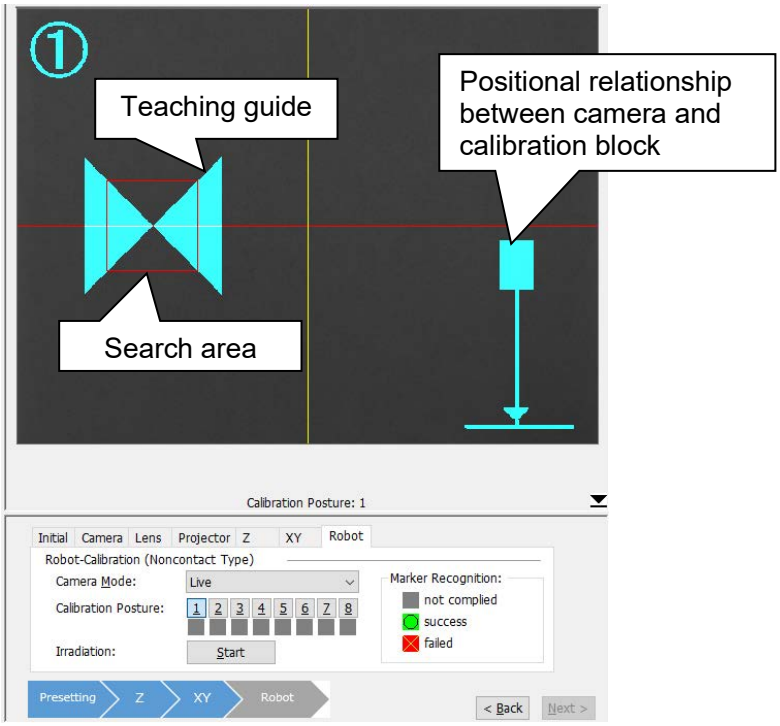


Fig. 7-71 Robot calibration

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).

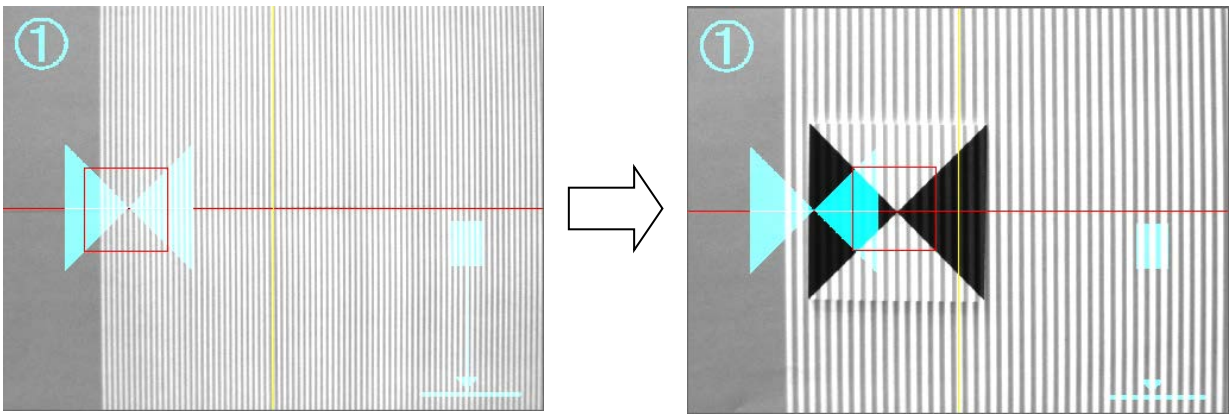
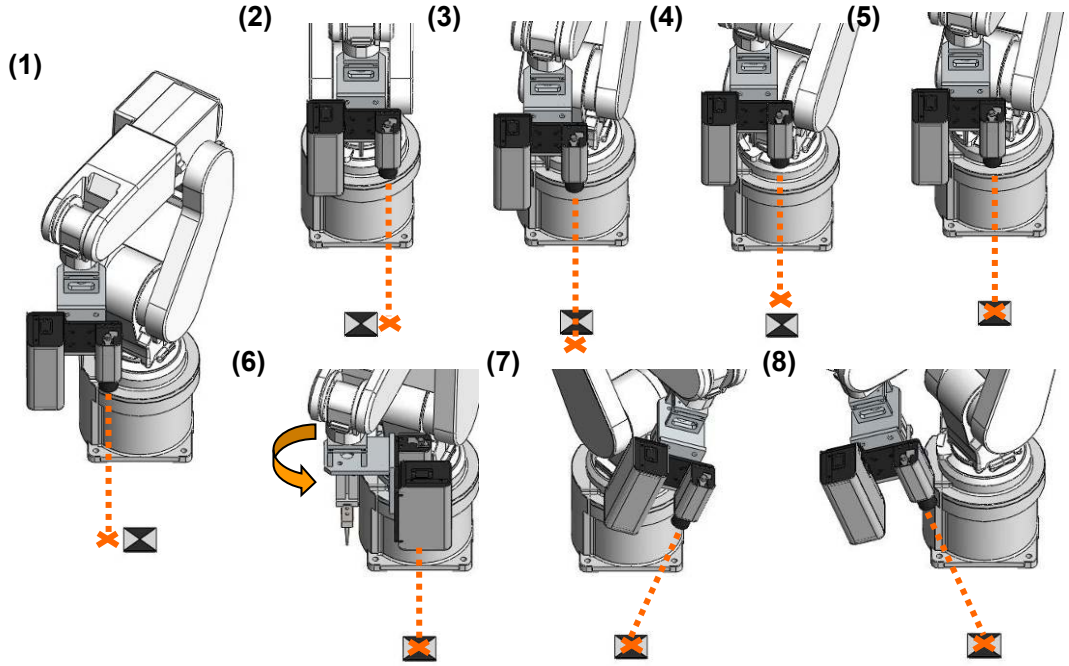


Fig. 7-72 Adjustment of the search range

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. 7-73.
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. 7-70.



(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. 7-73 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. 7-70.
- 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 7-12 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. 7-74 appears when the results for all eight postures are successful. The robot calibration can be completed depending on the displayed score.

Table 7-13: Required score for each recognition method

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

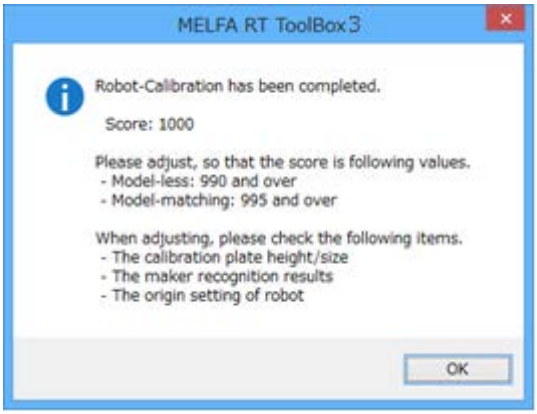


Fig. 7-74 Robot calibration score

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

Table 7-14: 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. 7-70Fig. 7-70 ?	Jog the robot to the range position shown in Fig. 7-70.
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. 7-72.	Adjust to ensure that the pattern irradiation enters the red frame in the search area as shown in Fig. 7-72.
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 recognition result image distorted?	Perform the lens distortion correction. Refer to 7.11.5 Distortion correction".
7	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 No. 4 to 6 in 10.5 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.

7.11.8.2. 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.

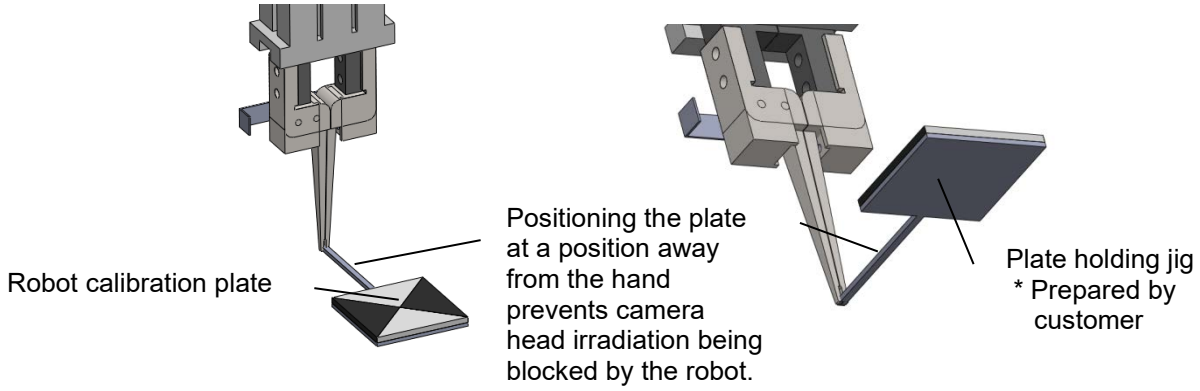


Fig. 7-75 Calibration plate attachment examples

◇◆◇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.

Teaching the calibration postures (8 points)

Attach the robot calibration plate to the robot hand.

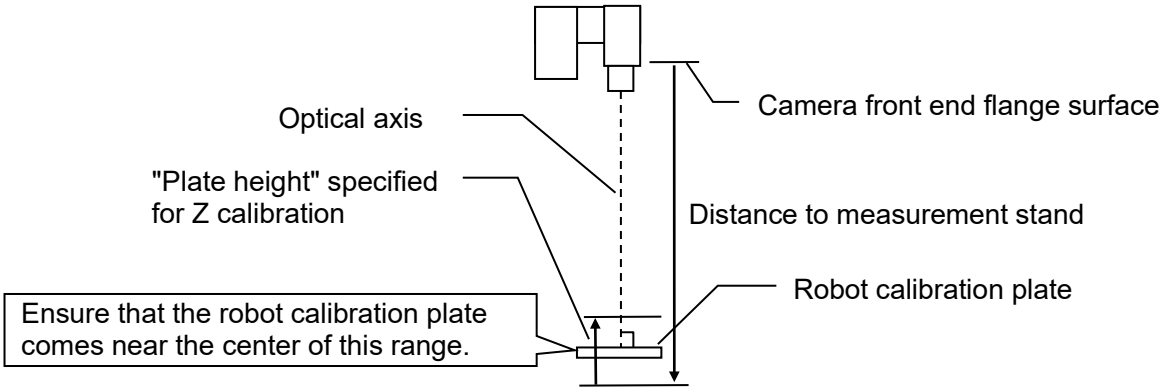


Fig. 7-76 Distance to robot calibration plate

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. 7-78. 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.

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. 7-77). 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.

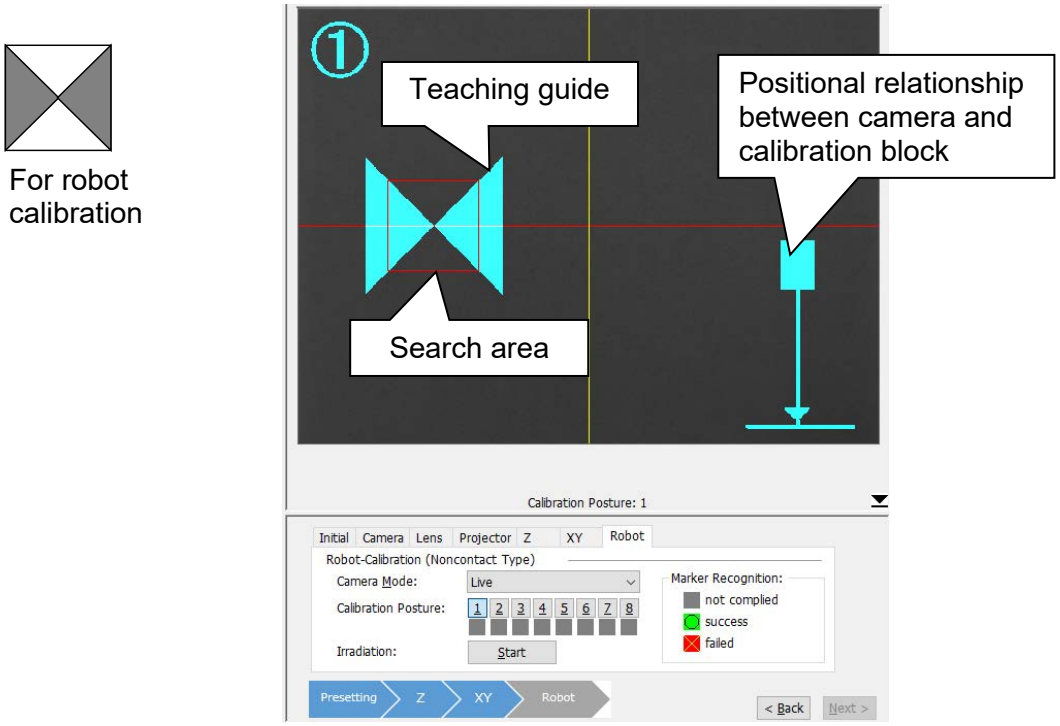


Fig. 7-77 Robot calibration

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).

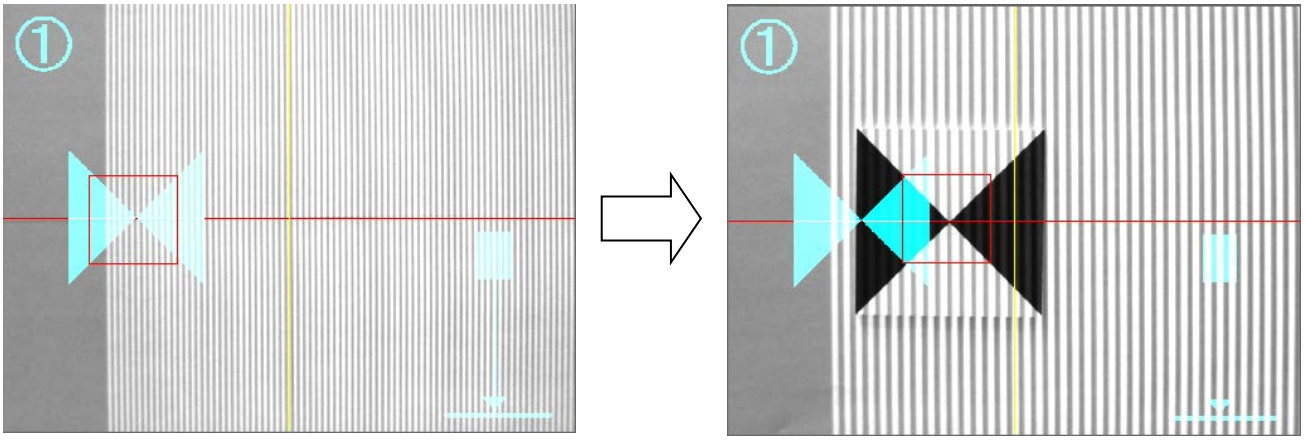
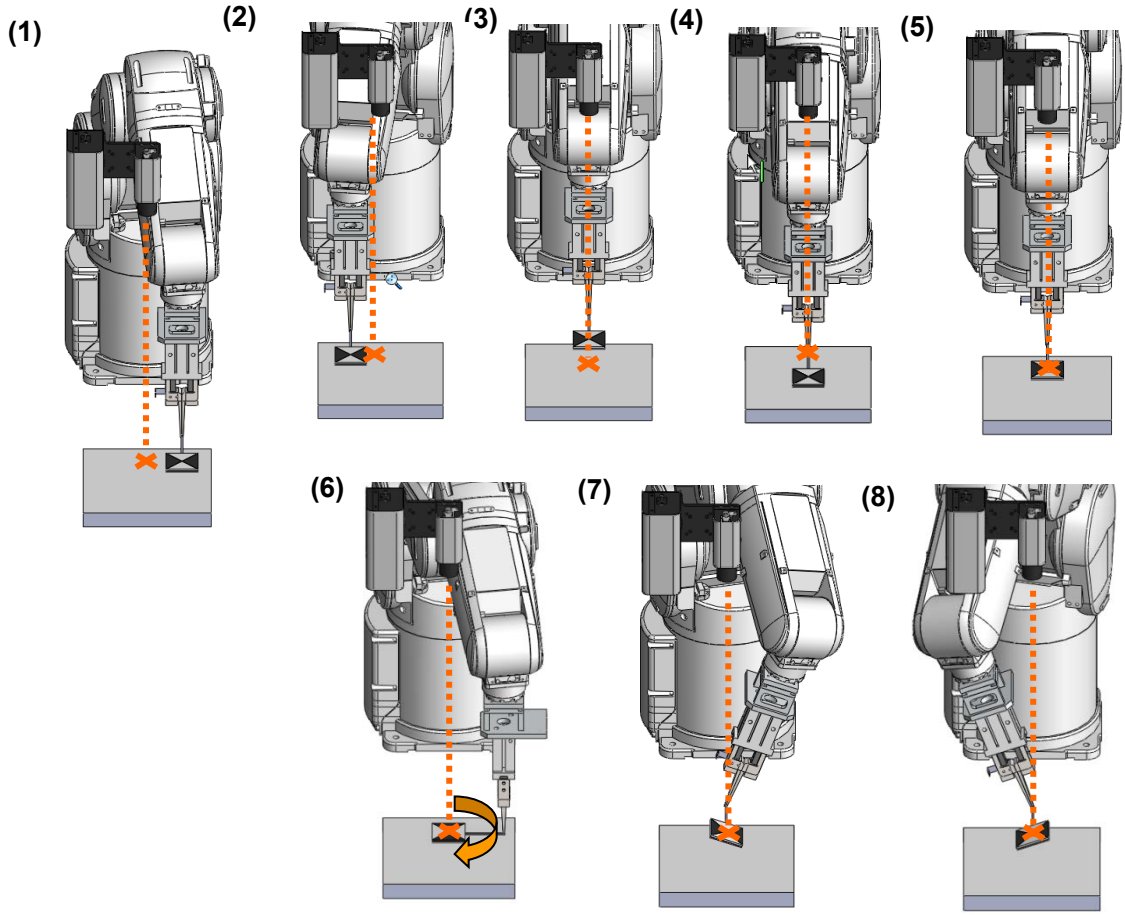


Fig. 7-78 Adjustment of the search range

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 inFig. 7-76.



(1) to (5): Move the XY-axis and align with the teaching guide. Do not change the A, B, or C components.
(6): Rotate 90º on the calibration mark center and align with the teaching guide.
(7), (8): After moving the B-axis ±20º, 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. 7-79 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. 7-76.
- 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, if the robot movement range is insufficient.

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

Table 7-15 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. 7-80 appears when the results for all eight postures are successful. The robot calibration can be completed depending on the displayed score.

Table 7-16: Required score for each recognition method

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

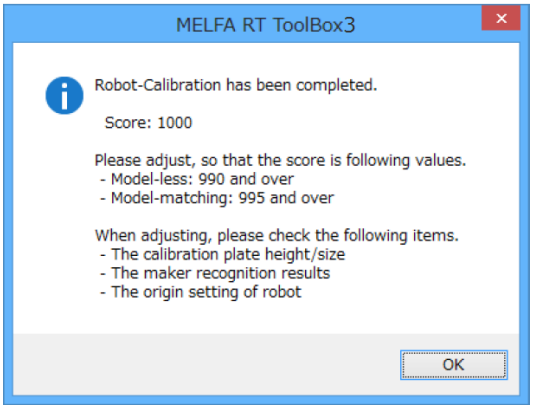


Fig. 7-80 Robot calibration score

If the robot calibration fails, check the following.

Table 7-17: 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. 7-70.	Jog the robot to the range position shown in Fig. 7-70.
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. 7-72 ?	Adjust to ensure that the pattern irradiation enters the red frame in the search area as shown in Fig. 7-72.
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 10.5 Q&A.

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

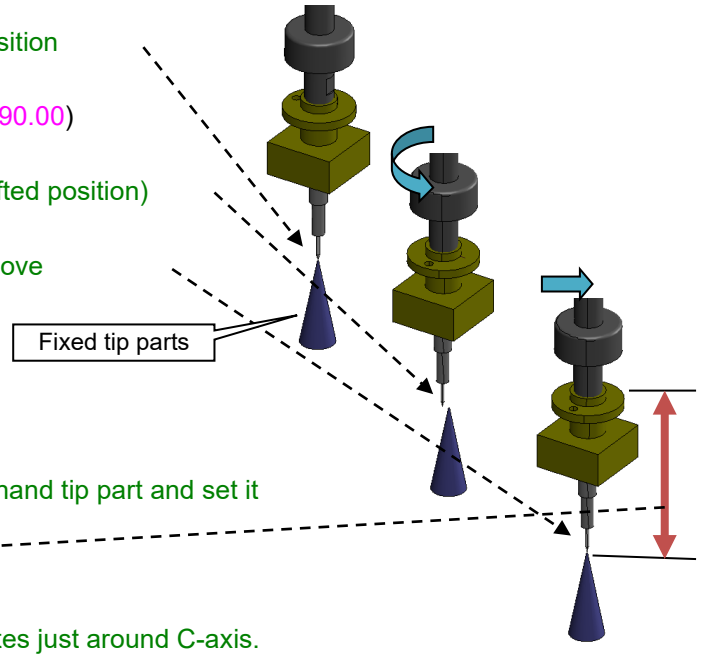
7.11.8.3. Fixed camera (Contact type)

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.

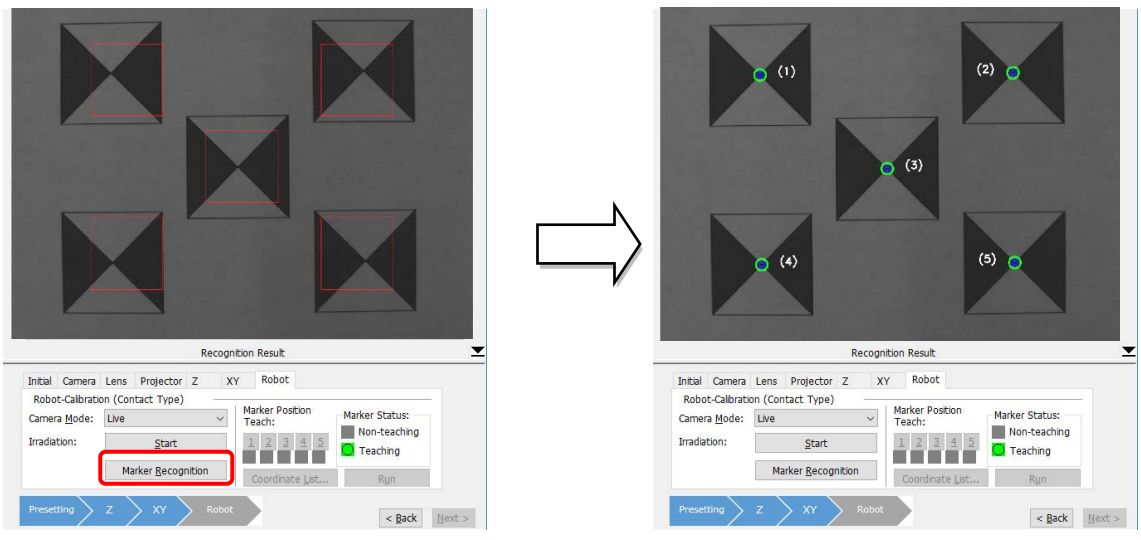


Fig. 7-81 Marker recognition

◇◆◇ When the mark is not within the red frame ◇◆◇

Click the red frame to move so that the center of the mark is within the red frame (Refer to Fig. 7-81).

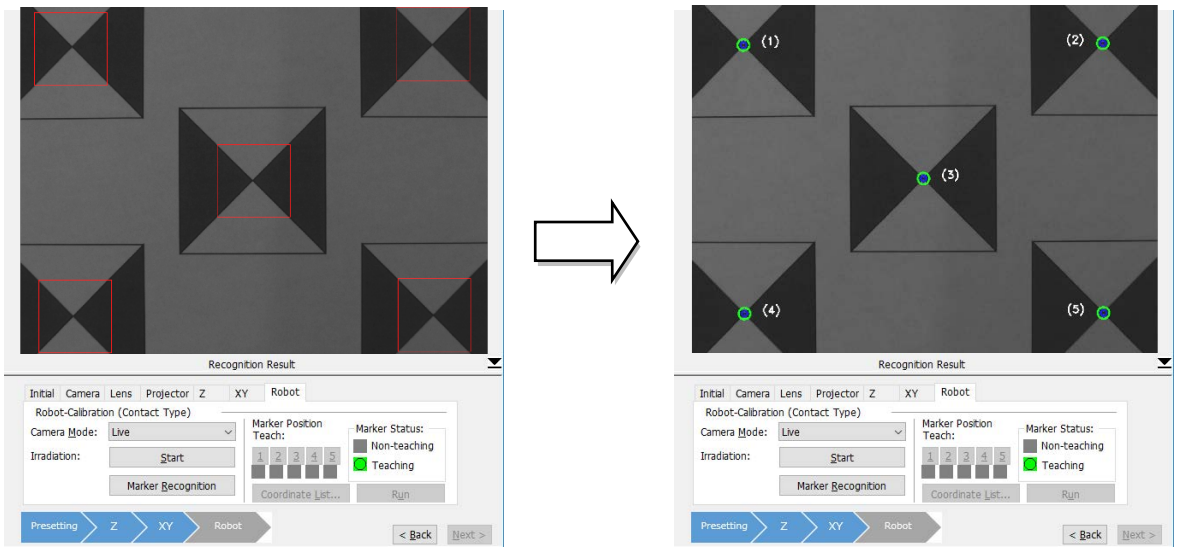


Fig. 7-82 Marker recognition (when the mark is not within the red frame)

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.

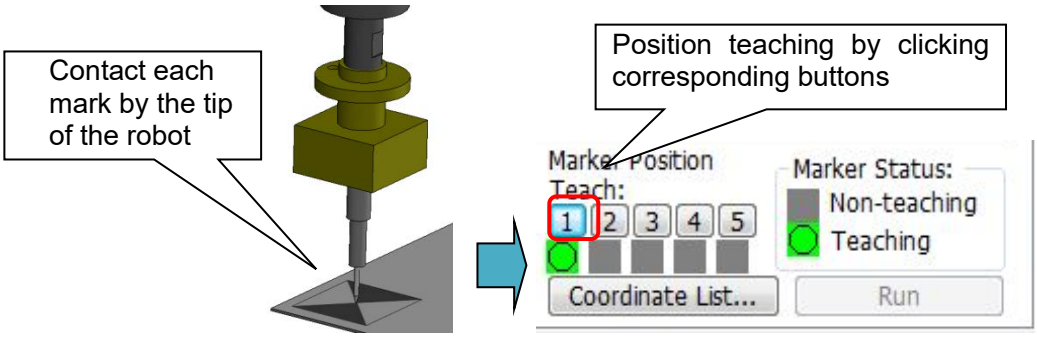


Fig. 7-83 Teaching operations at robot calibration

◇◆◇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.

Please repeat this operation to each mark.

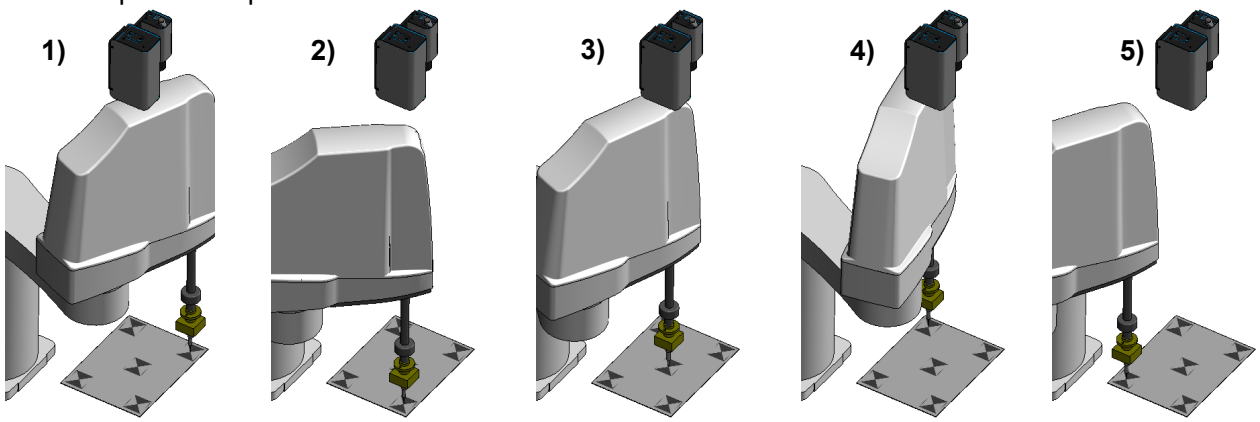


Fig. 7-84 Robot operation examples at robot calibrations

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

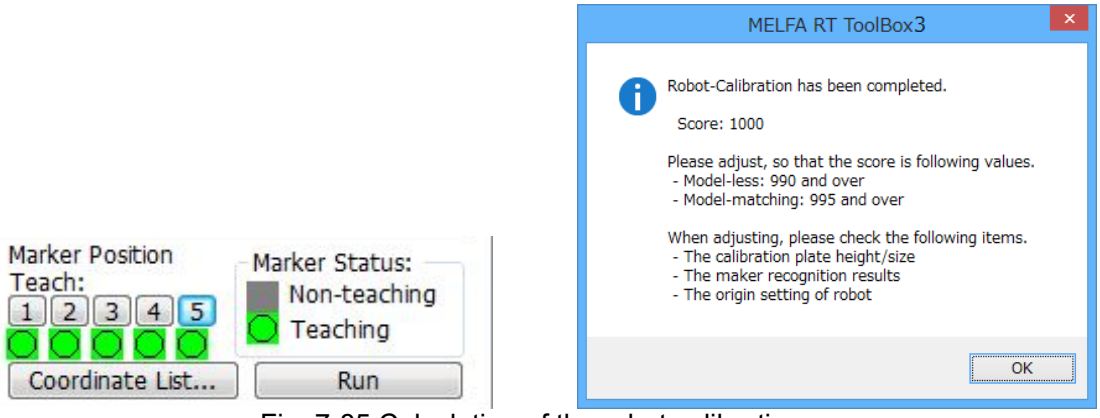


Fig. 7-85 Calculation of the robot calibration

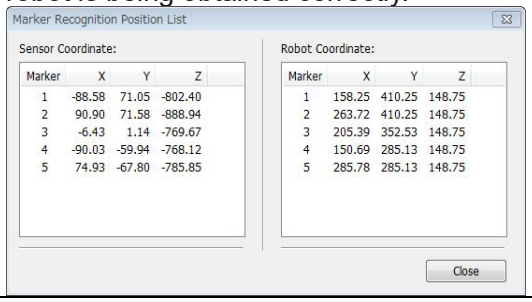
Please finish the operation of robot calibration by judging displayed score.

Table 7-18 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 7-19 Check items when the robot calibration is failed

No.	Check items	Action
1	Is there disturbing light Note 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

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

7.11.9. Editing and deleting the calibration data

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.

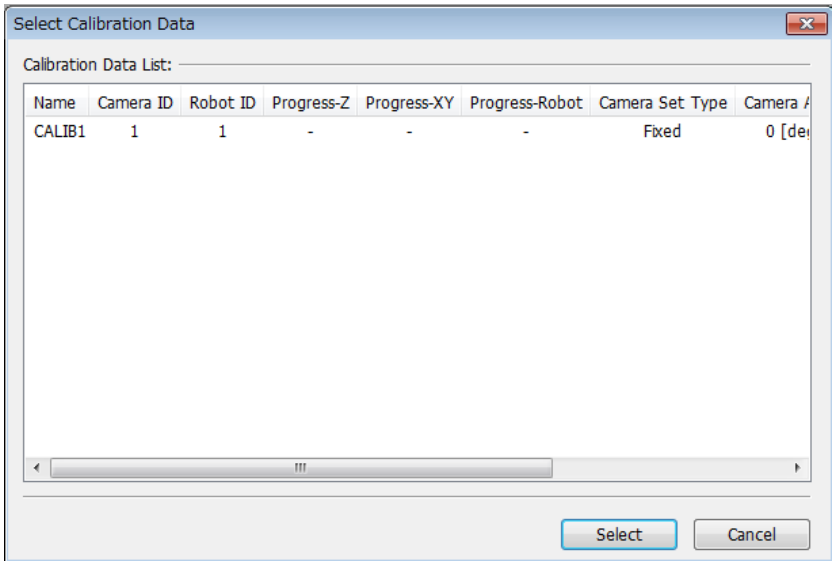


Fig. 7-86 Selection of calibration data

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.

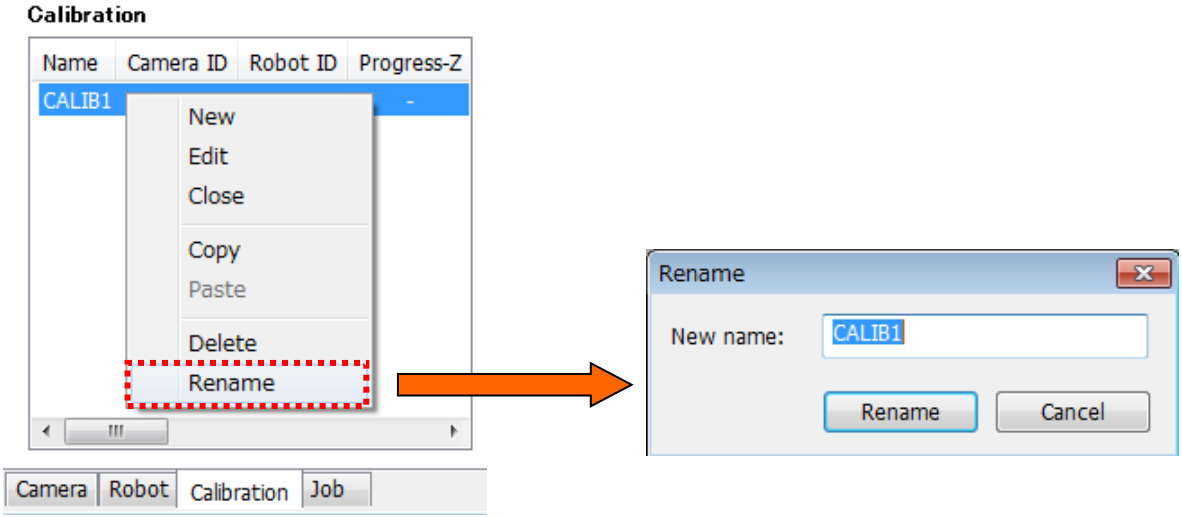


Fig. 7-87 Changing the calibration data name

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.

7.12. 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.

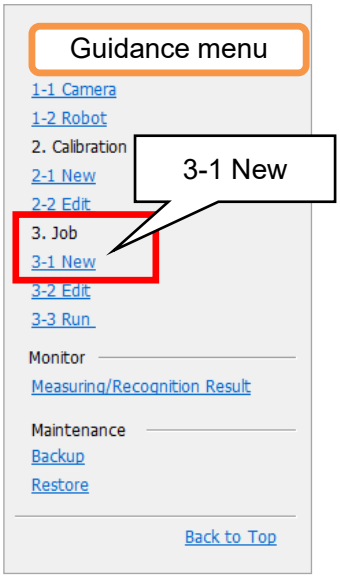


Fig. 7-88 Measurement/recognition

◇◆◇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.

7.12.1. 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.

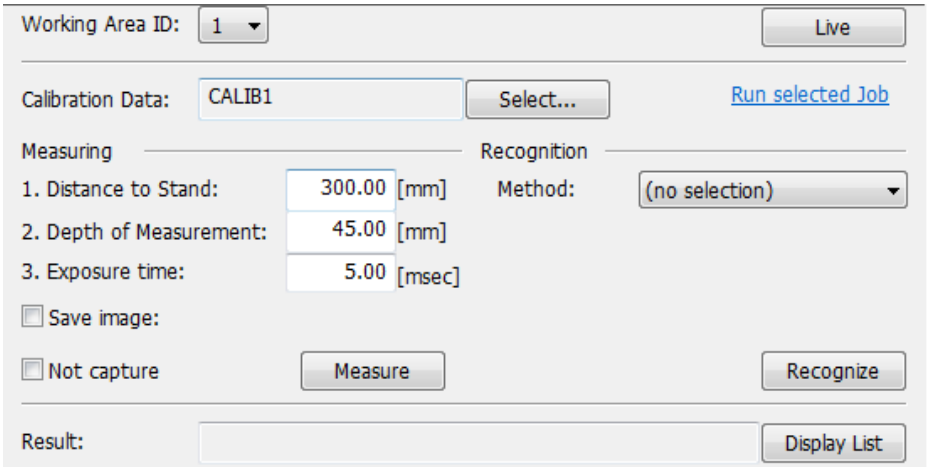


Fig. 7-89 Measurement/recognition settings

7.12.2. Measurement settings

Input the distance to the measurement stand, measurement depth and exposure time.
Enter the following values.

Table 7-20: 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)	

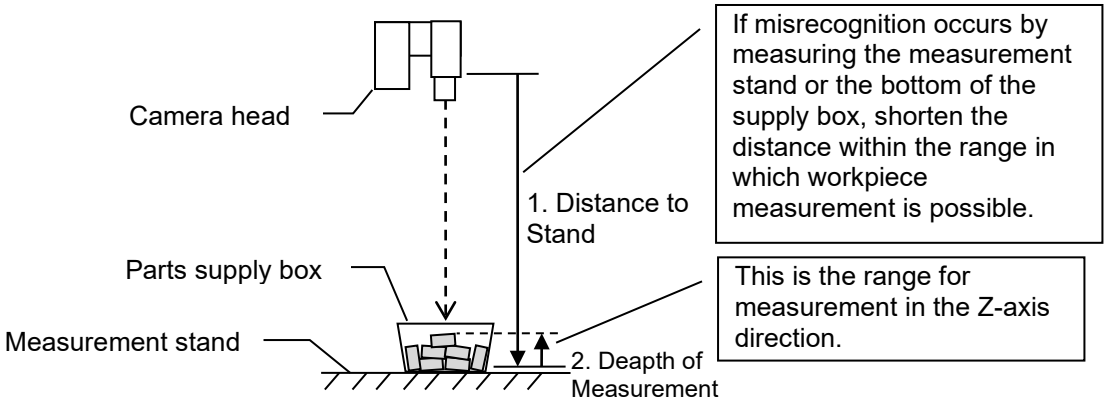


Fig. 7-90 Distance to measurement stand and measurement depth

◇◆◇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.

Select the "Save measurement data" and "Do not capture" check boxes if required.

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 7-21 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.

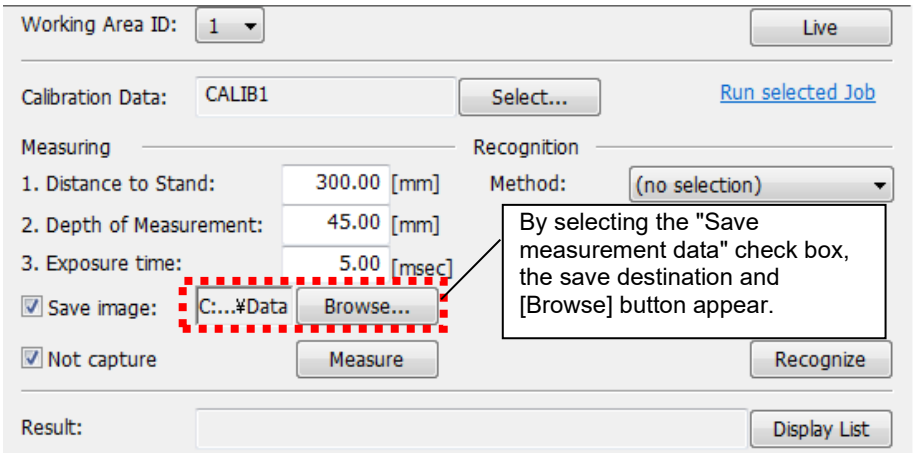


Fig. 7-91 Check box for "Save the measured data"

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.

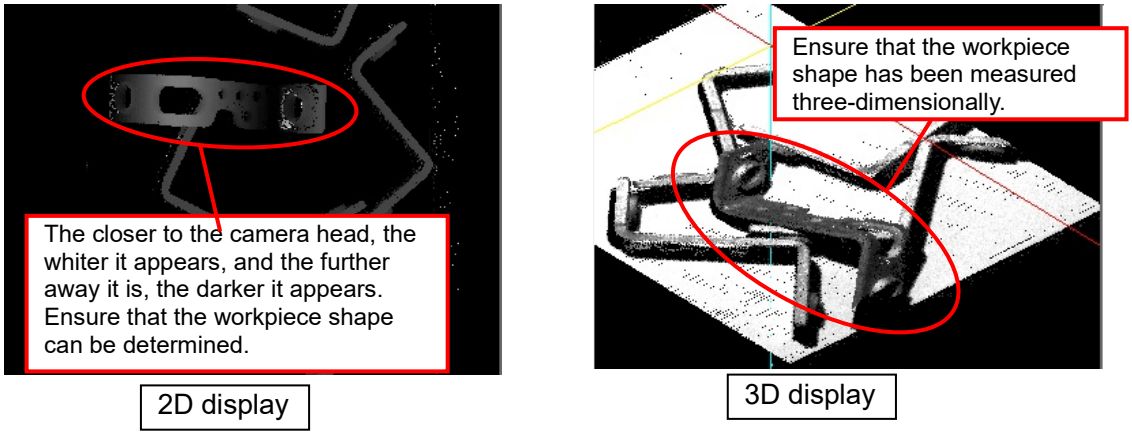


Fig. 7-92 Measurement results check

◇◆◇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.

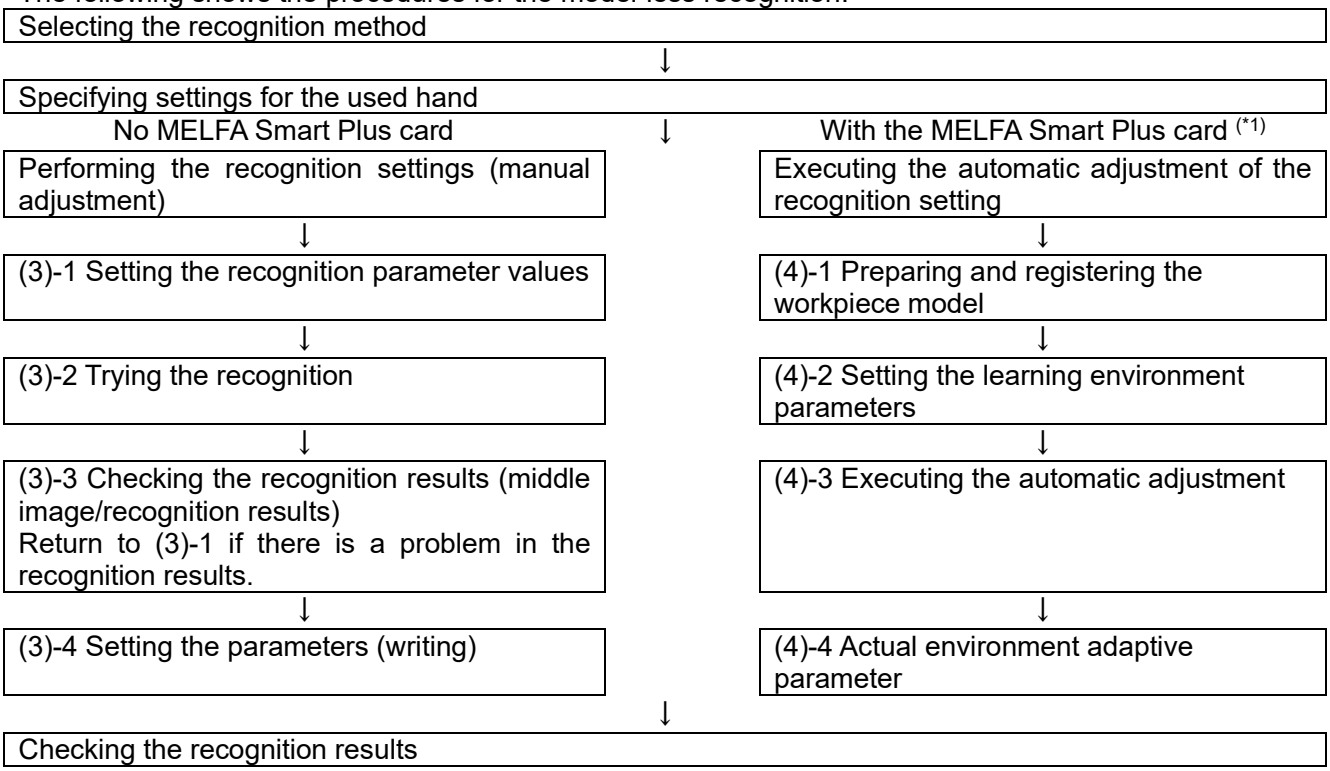
7.12.3. Recognition settings

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.

7.12.3.1. 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 "7.13.1 Hand claw shape".

The following shows the procedures for the model-less recognition.



(*1): For the corresponding model names, refer to "4.1 Product Check".

(1) Selecting the recognition method

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

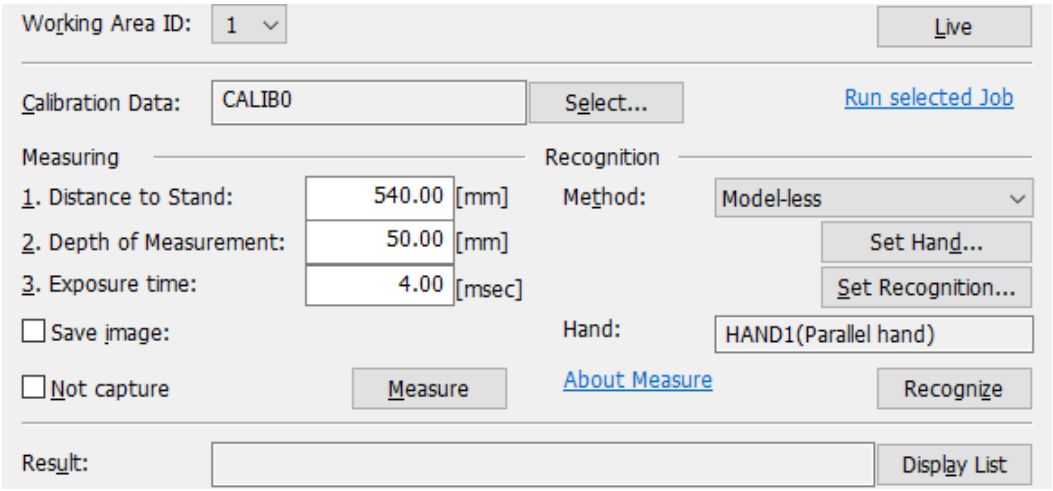


Fig. 7-93 Selection of recognition methods (model-less recognition)

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

Table 7-22: 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.	
Hand	The hand type to be used set in the hand settings is displayed.	

(2) Specifying settings for the used hand

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 7-23 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

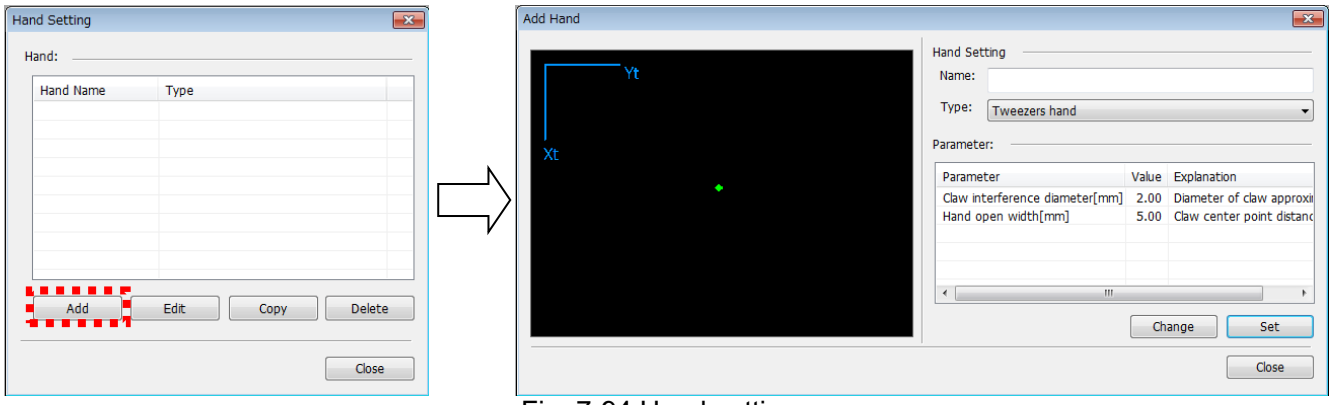


Fig. 7-94 Hand settings

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

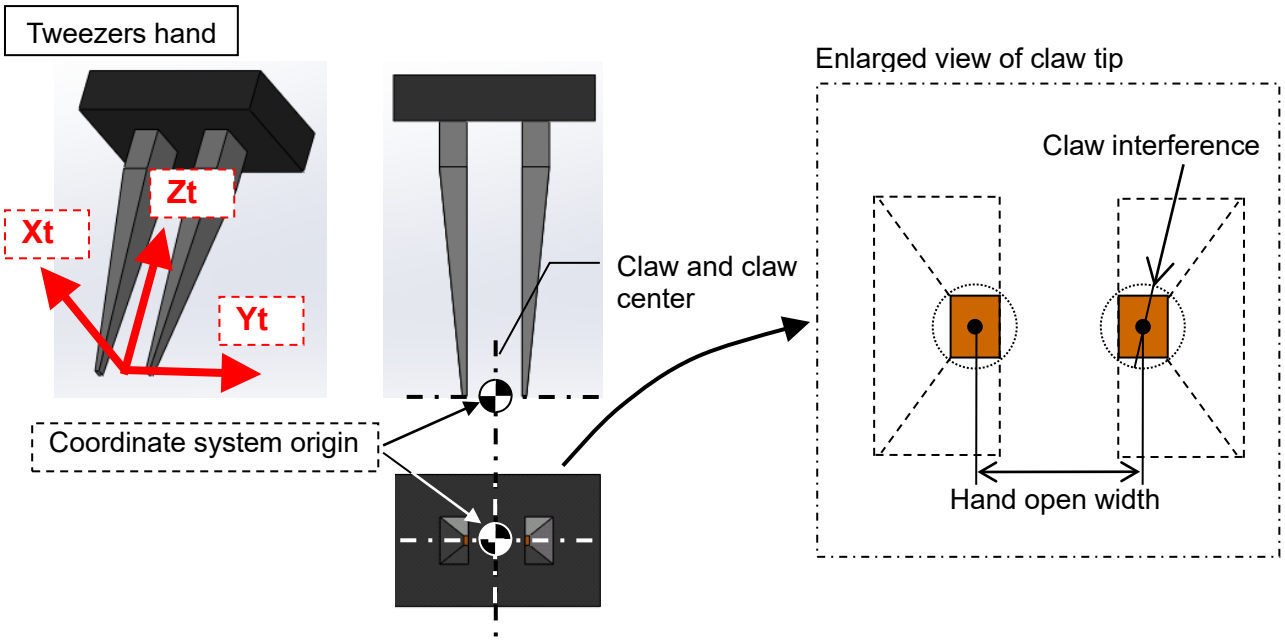


Fig. 7-95 Hand coordinate system and hand parameters (Tweezers, Suction Hand)

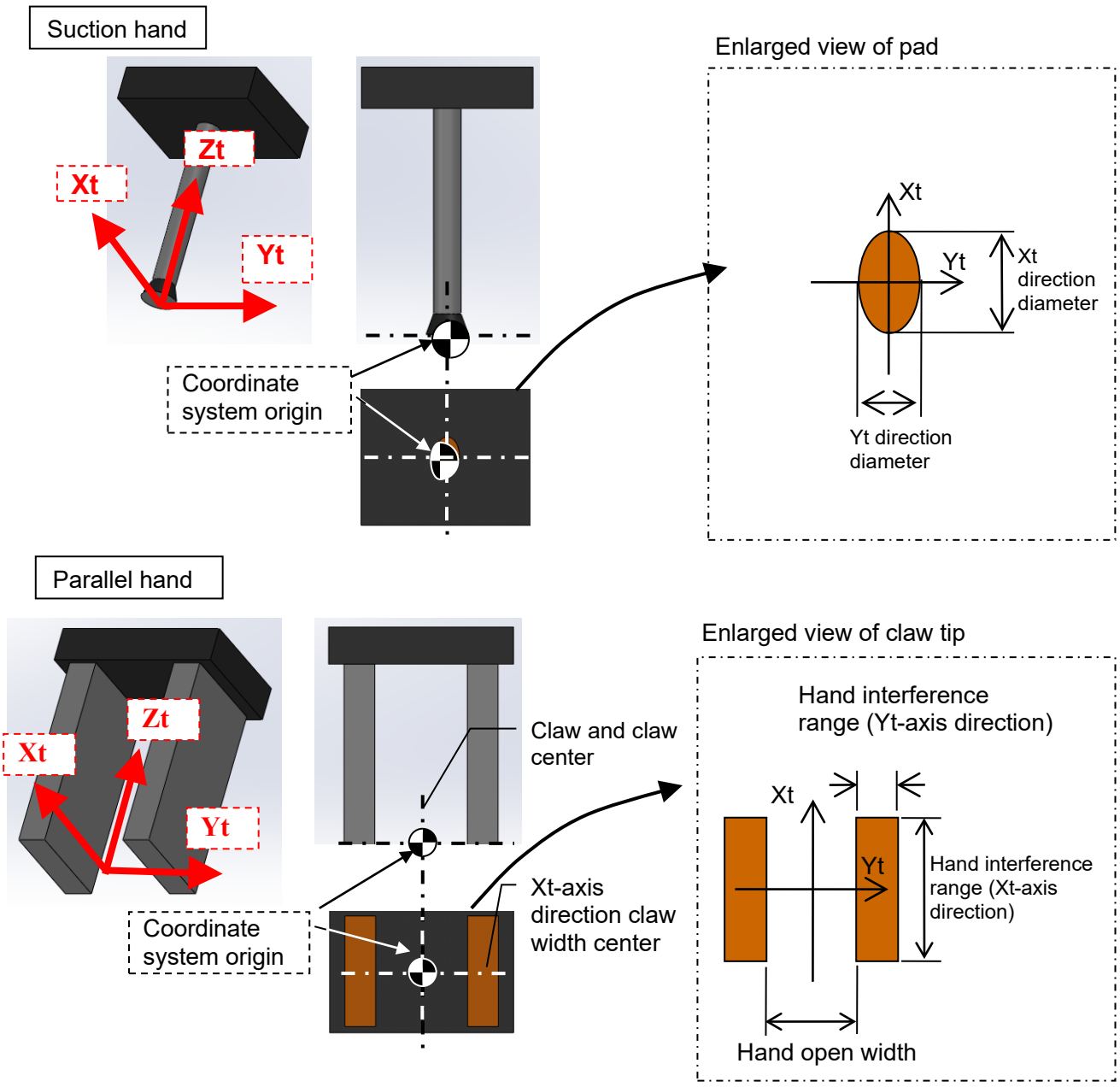
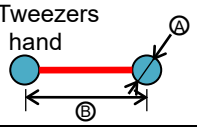
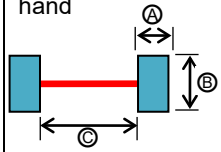
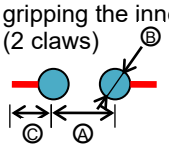
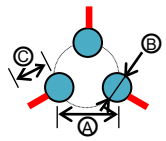
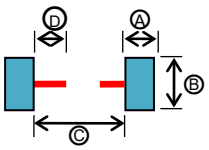
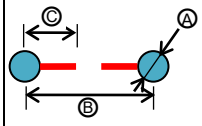
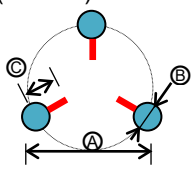
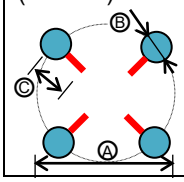


Fig. 7-96 Hand coordinate system and hand parameters (Parallel hand)

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

Table 7-23 : Hand types and parameters

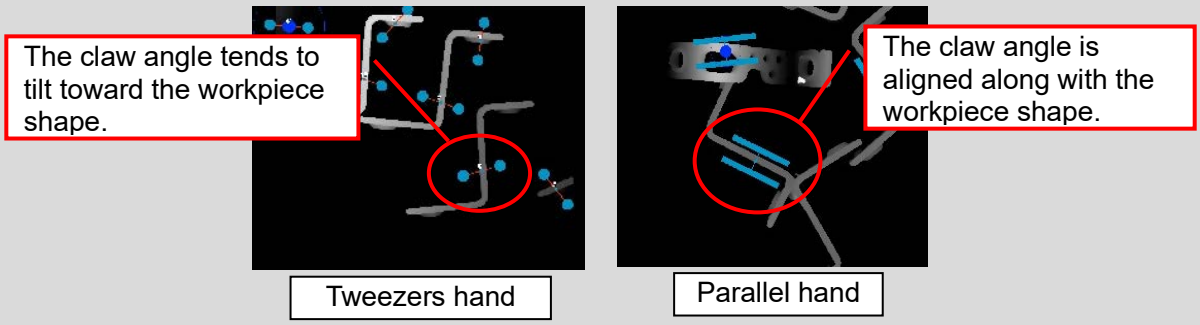
Hand type	Parameter	Unit	Description	Range	Default setting	Automatic adjustment*
Tweezers hand 	Claw interference diameter Ⓐ	mm	Diameter of claw approximated with circle	0.5 to 50	2	
	Hand open width Ⓑ	mm	Claw center point distance when hand open	0.5 to 200	5	○
Suction hand 	Yt-axis direction diameter Ⓐ	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 	Claw interference diameter (Yt-axis direction) Ⓐ	mm	Yt-axis direction claw length in hand coordinate system	0.5 to 100	1	○
	Claw interference diameter (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 type	Parameter	Unit	Description	Range	Default setting	Automatic adjustment*
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	
Parallel Hand (Limited stroke) 	Claw interference diameter (Yt-axis direction) Ⓐ	mm	Yt-axis direction claw length in hand coordinate system	0.5 to 100	1	
	Claw interference diameter (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	

*The circle mark "○" indicates the automatic adjustment parameter.

◇◆◇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.



◇◆◇Registered hand settings◇◆◇

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

(3) Performing the recognition settings (manual adjustment)

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

(3)-1 Setting the recognition parameter values

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.

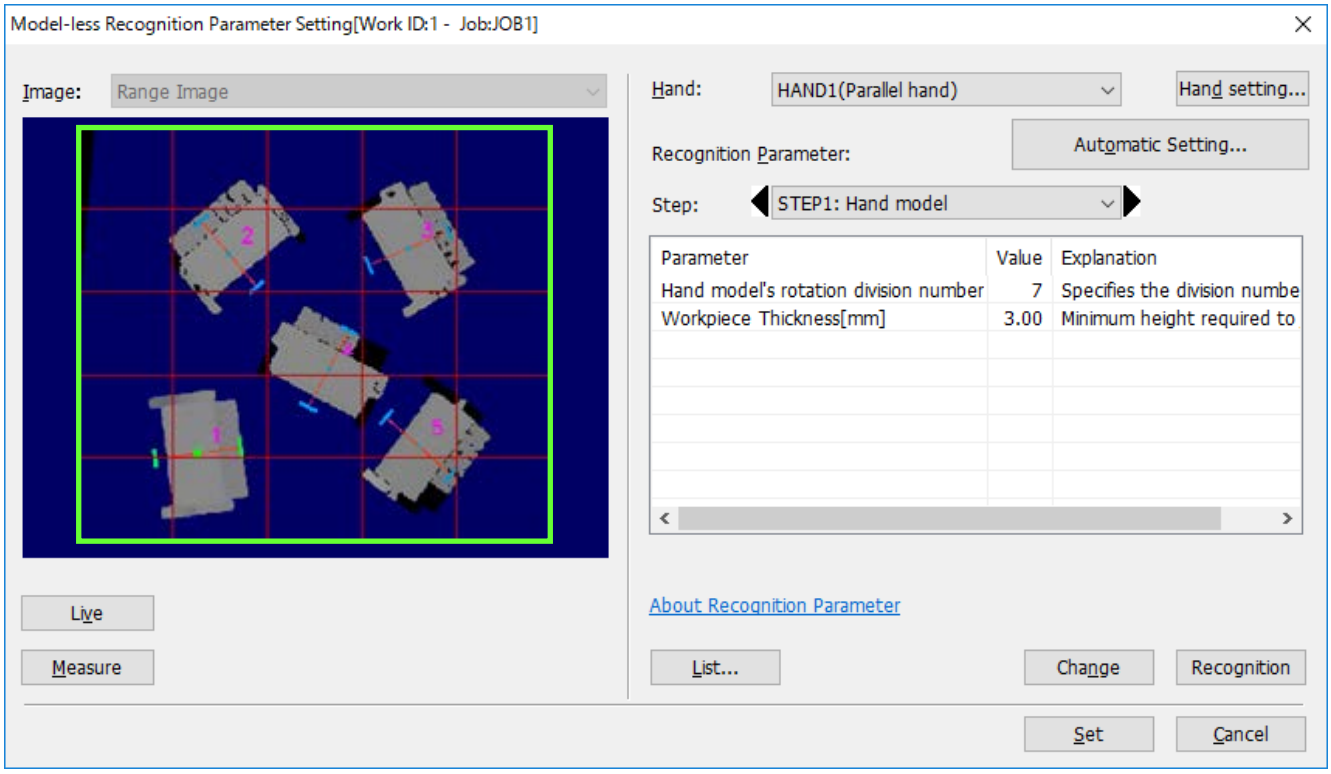


Fig. 7-97 User settings for model-less recognition

Table 7-24: Recognition parameters

Parameter	Unit	Description	Range	Default setting	Automatic adjustment*
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	0 to 255	10	
Recognition range X start point Note 3	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+)	10 to 1260	100	
Recognition range X end point Note 3	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+)	20 to 1270	1180	
Recognition range Y start point Note 3	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+)	10 to 940	50	
Recognition range Y end point Note 3	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+)	20 to 950	950	
Number of Horizontal Recognition Area Divisions (X direction)	-	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 (Y direction)	-	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 Note 4	mm	Set the margin of the recognition range.	-50 to 100	0.0	
Height of box Note 4	mm	Set the height of the box.	0 to 300	0.0	
Boundary output Note 5	%	Disabled: the recognition result within the recognition range is output. Enabled: the workpiece that exists at the boundary of the recognition range is output as recognition result. However, part of the hand may out of the recognition range, so please be careful with interference with surroundings.	0.0 to 100.0	10.0	
STEP 3: Outline extraction					
Edge Identification sensitivity	-	Threshold of edge strength for segmentation.	1 to 1000	30	○

Parameter	Unit	Description	Range	Default setting	Automatic adjustment*
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 area per part	mm^2	The minimum area inside of viewing the workpiece from various angles. By increasing the value, candidates for workpiece are narrowed down. However, if the value is set too large, the workpiece may not be detected.	1 to 33600	100	○
Maximum area per part	mm^2	The maximum area insideof viewing the workpiece from various angles. By decreasing the value, candidates for workpiece are narrowed down. However, if the value is set too small, the workpiece may not be detected.	1 to 168000	168000	○
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 7	-	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	
Main axis feature mode Note 7	-	Swith the main axis feature mode (length feature, angle estimate)	0: Disable 1: Length 2: Angle 3: Length + Angle	0	○
Minimum main axis length Note 7	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	1 to 250	10	○
Maximum main axis length Note 7	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	10 to 1000	100	○
Minimum main axis ratio Note 7	%	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	0 to 100	0	○
Maximum main axis ratio Note 7	%	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	0 to 100	100	○

Parameter	Unit	Description	Range	Default setting	Automatic adjustment*
Posture output Note 9	-	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) 5: Robot coordinates (component A, B, and C, RV type) 6: Robot coordinates (components A, B and C, RH type) 0: Posture in the camera coordinates system is output. 1 to 6: Posture in the robot coordinates system is output. Select 2, 4, 5, or 6 when the grip force for the normal direction of the object is expected. * Regarding the camera coordinates system, refer to Fig. 3-10. * The robot coordinates system is the base coordinates system.	0 to 6	1	
Recognized candidates output	-	Sort the order of the recognized candidates.	1: Graspabiity (descendling order) 2: Average Height (descending order) 21: Grasperbility x Average Heigh (descending order)	21	
Calculation processing of the residual percentage against the full measurement volume Note10) Note 11)	-	Calculate the residual percentage against the full measurement volume by enabling this function. Remain 1: Workpiece residual rate calculated based on the height information (component Z) Remain 2: Workpiece residual rate calculated based on the recognition range information (component XY)	0: Disabled 1: Enabled	0	

*The circle mark "○" indicates the automatic adjustment parameter.

Note 1: Hand model rotation angle resolution
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: Hand model rotation angle resolution
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: As the recognition range widens, the recognition time gets longer.
Upper Left: Origin, Right direction: +X, Down direction: +Y.

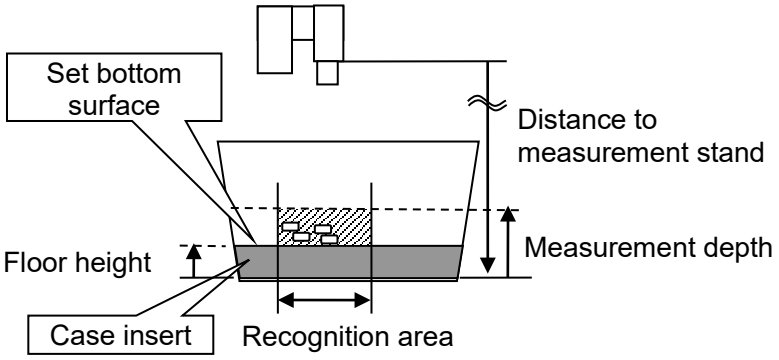


Fig. 7-98 Definition of the bin floor height and the recognition domain

Note 4: Margin in the recognition area and box height

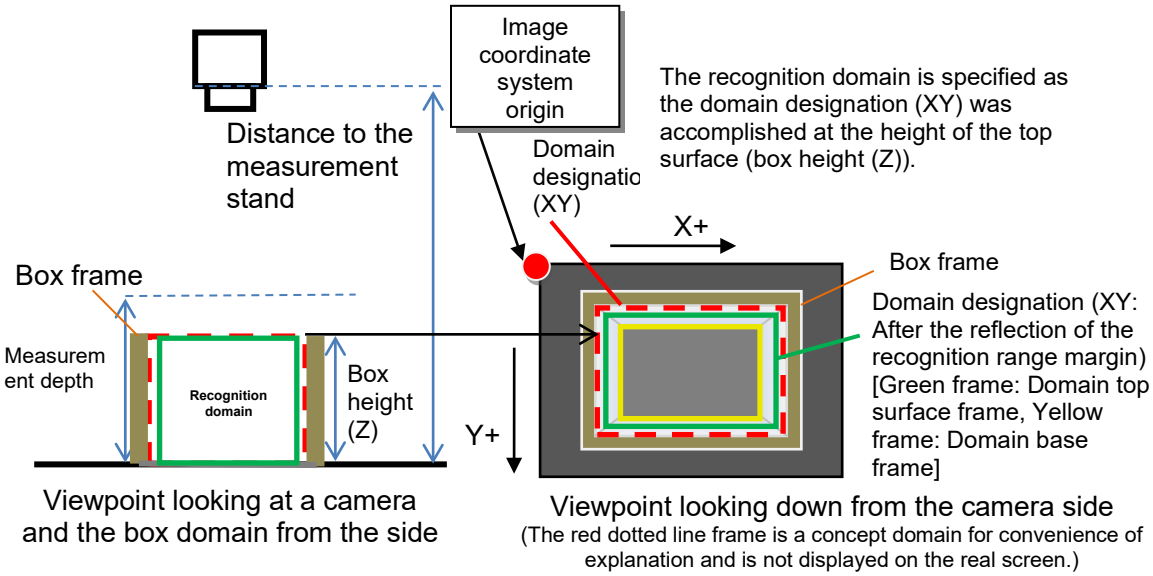


Fig. 7-99 Explanatory drawing for the recognition domain (recognition range margin, height of box)

Note 5: Boundary output

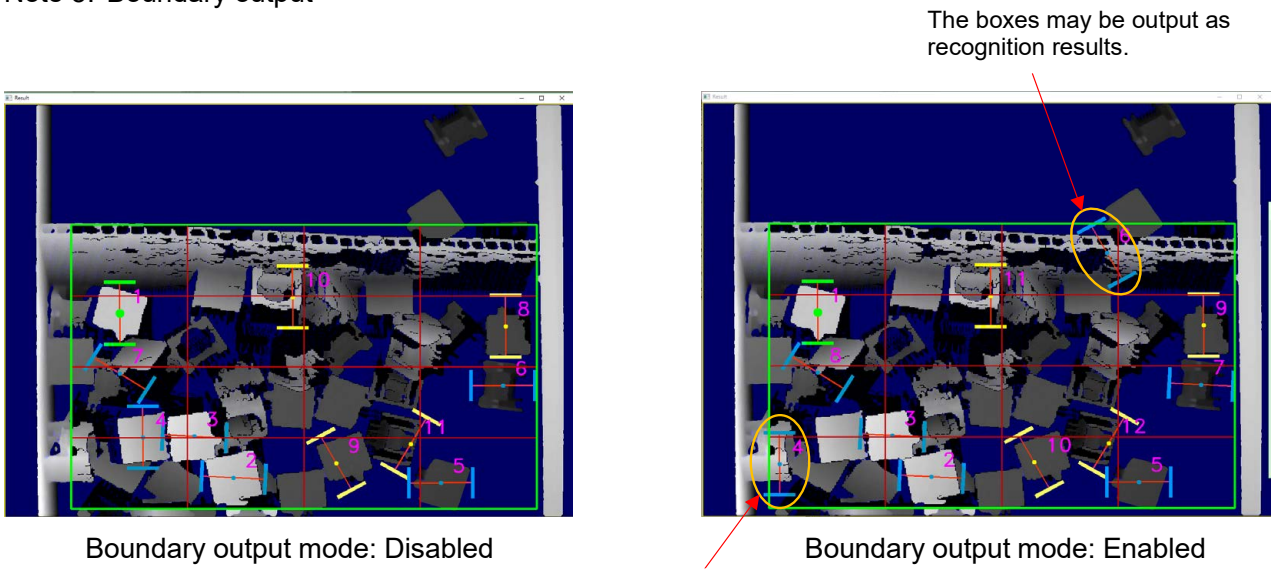


Fig. 7-100 Differences between the boundary output mode enabled and disabled

Note 6: Maximum area in the workpiece appearance

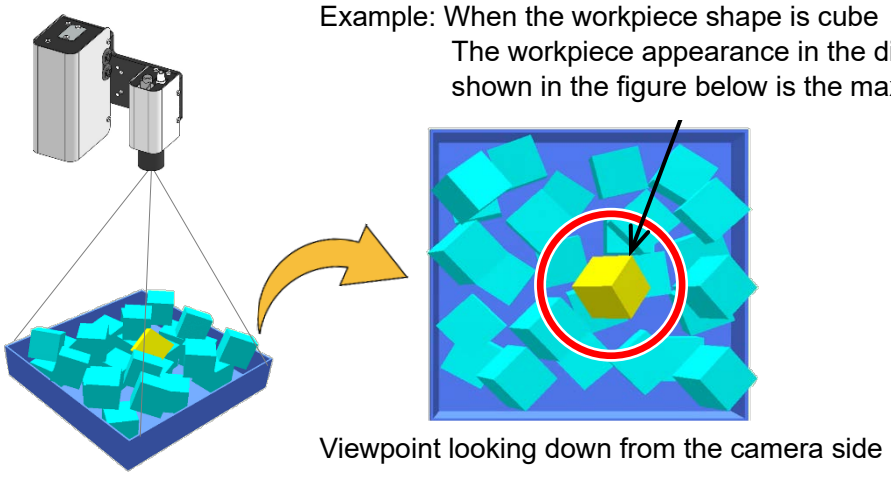


Fig. 7-101 Example of the maximum area in the workpiece appearance

Note 7: 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 8: Features of the main axis

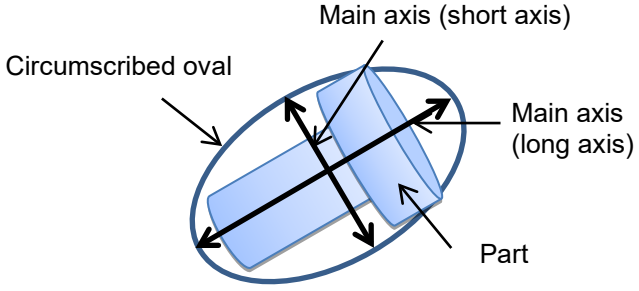


Fig. 7-102 Definition for the main axis feature mode

Note 9: Addition of the posture output mode

By setting the posture output mode, the workpieces can be gripped according to their tilt.
The following shows the posture output image. The postures of the component C, BC, and ABC are shown from the left.
To grip the bar-shaped workpieces according to their tilt, use mode "2" or "4" in which the component BC posture can be output.
To grip the bar-shaped workpieces according to their workpiece tilt, use mode "5" or "6" in which the component ABC posture can be output.

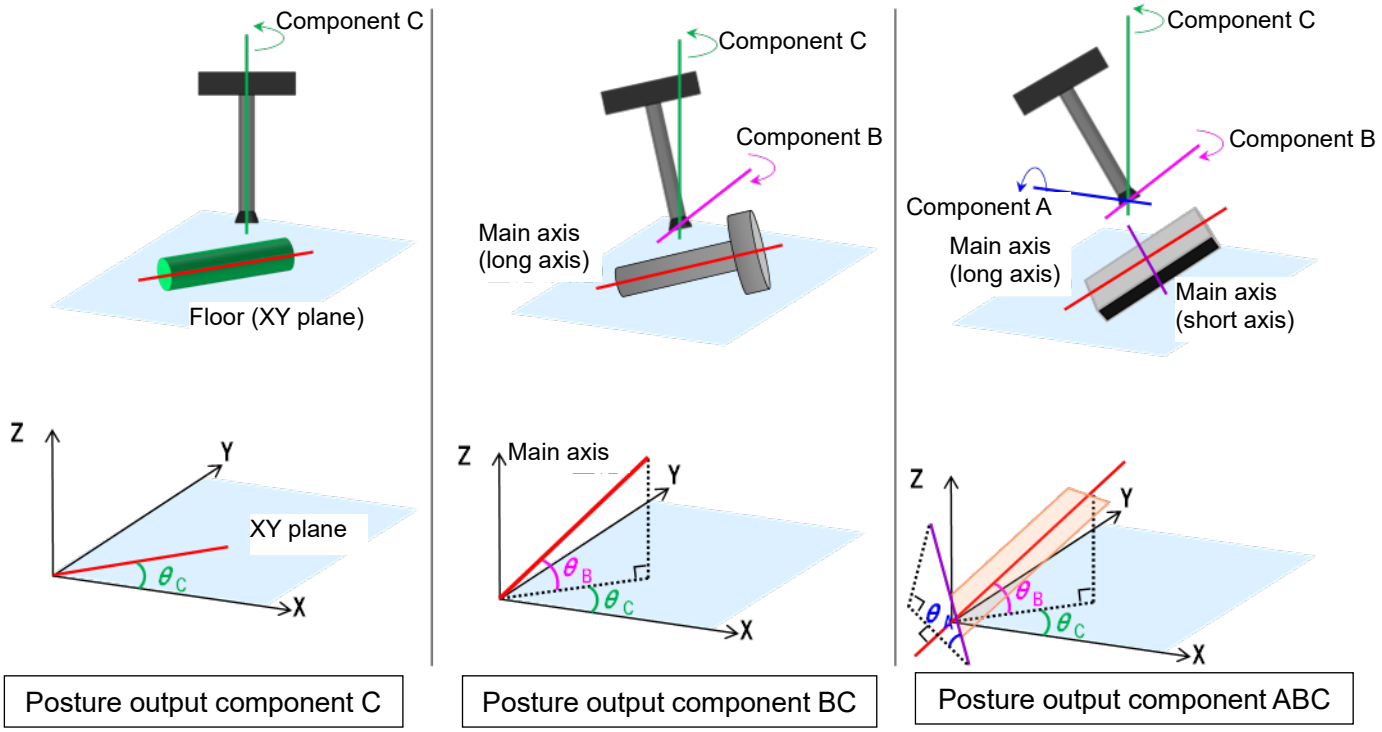


Fig. 7-103 Posture output image

Note 10: 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 11: Workpiece residual amount display

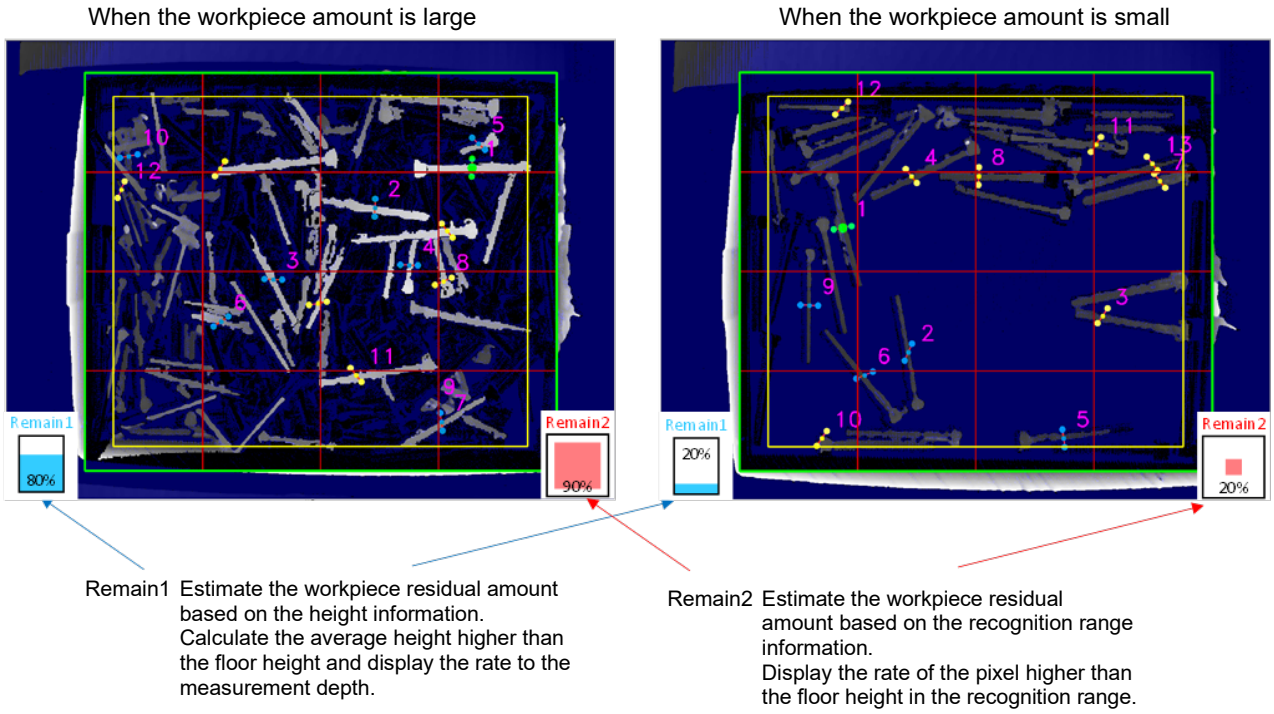


Fig. 7-104 Display example of the workpiece residual amount

For the workpiece residual amount, the following two viewpoints are considered and quantified.
・Remain1: Calculate the workpiece residual amount based on the height information (component Z). (0 to 100%)
・Remain2: Calculate the workpiece residual amount based on the recognition range information (component XY). (0 to 100%)

The following shows the workpiece residual rate definition (calculation method).

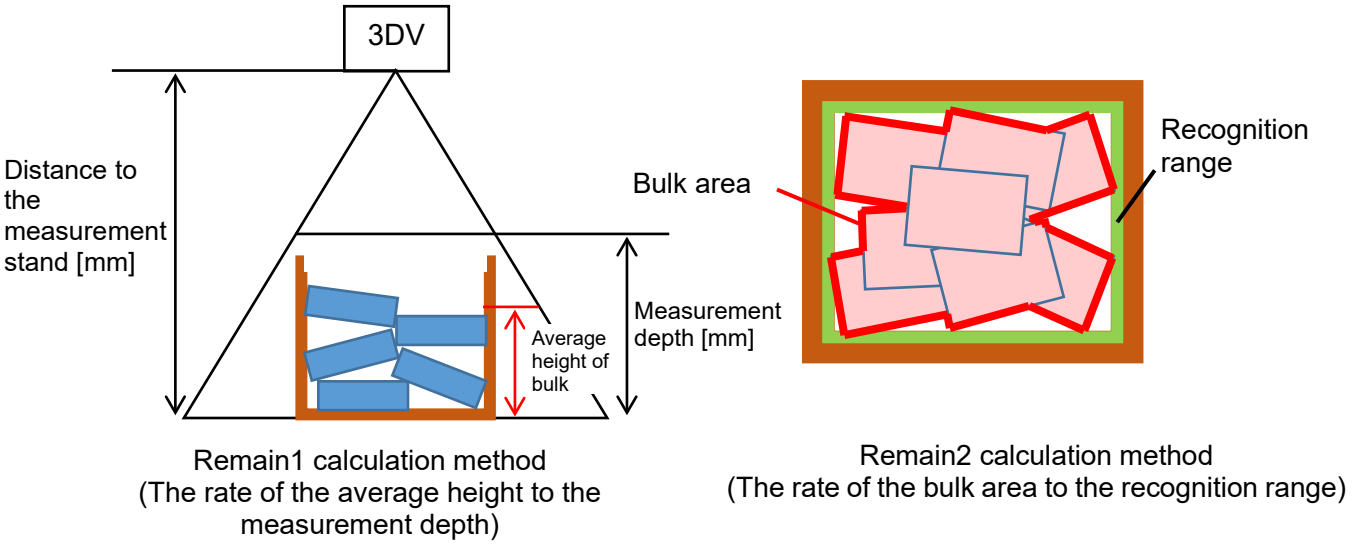


Fig. 7-105 Workpiece residual rate definition (calculation method)

The workpiece residual amount (condition) in the box can be estimated by using the values of Remain1 and Remain2. The following shows the relationship between the two values.

Table 7-25 Relationship between Remain1 and Remain2

		Remain1 (Workpiece residual rate calculated from the height information)	
		High	Low
Remain2 (Workpiece residual rate calculated from the recognition range information)	High	There are a lot of workpieces in the box.	The workpieces are stacked in bulk.
	Low	The workpieces are inclined to one side.	There are a few workpieces in the box.

The values of Remain1 and Remain2 are stored in the status variable (M_V3Rmn1, M_V3Rmn2) of the robot.
For details of the status variable, refer to "8.2 MELFA-3D Vision Related Status Variables".

(3)-2 Trying the recognition
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.

(3)-3 Checking the recognition results (middle image/recognition results)
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 7-26 shows a list of each STEP of the recognition parameters and the corresponding images, while Table 7-26 illustrates an example of an indication image.

Table 7-26: 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

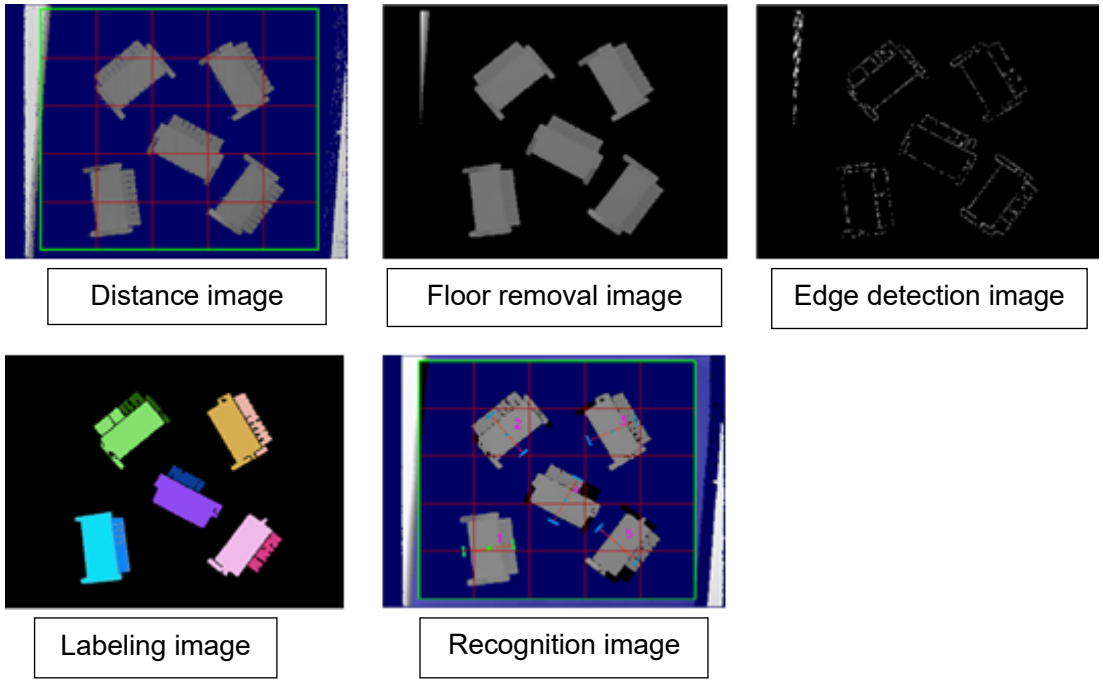


Fig. 7-106 Types of display images

(3)-4 Setting the parameters (writing)
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.

(4) Executing the automatic adjustment of the recognition setting

The following shows how to adjust the recognition setting automatically.

* To manually perform the recognition setting, follow " (3) Performing the recognition settings (manual adjustment) ".

The following shows the parameters that are adjusted automatically.

Table 7-27 Automatic adjusted recognition parameter

Parameter	Unit	Description	Range	Default setting
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
Edge Identification sensitivity	-	Threshold of edge strength for segmentation.	1 to 1000	30
Minimum area per part	mm^2	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.	1 to 33600	100
Maximum area per part Note 3	mm^2	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.	1 to 168000	168000
Smooth strength	-	The greater the value, the more noise is reduced.	-1: Original 0: No filter 1 to 4	4
Full search mode: 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	1
Main axis feature mode Note 4	-	Swith the main axis feature mode (length feature, angle estimate)	0: Disable 1: Length 2: Angle 3: Length + Angle	0
Minimum main axis length Note 4	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	1 to250	10
Maximum main axis length Note 4	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	10 to 1000	100
Minimum main axis ratio Note 4	%	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	0 to 100	0
Maximum main axis ratio Note 4	%	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	0 to 100	100

Note 1: Hand model rotation angle resolution

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.

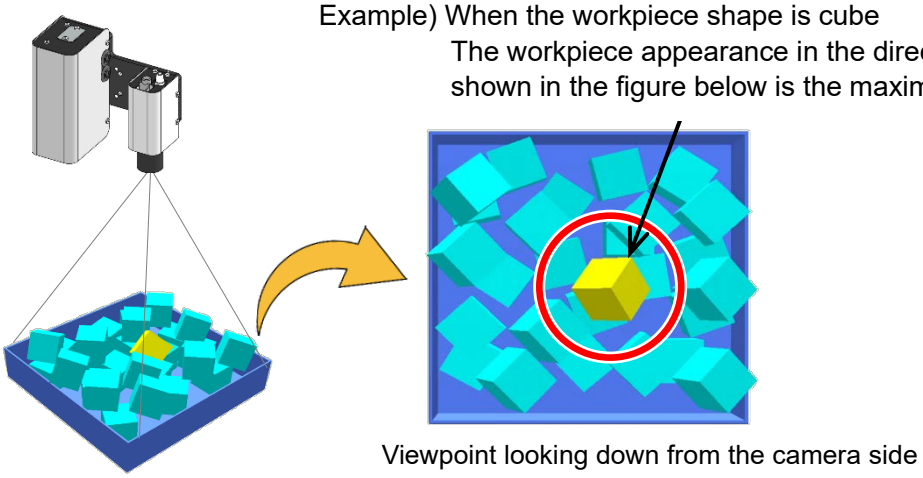
Note 2: Hand model rotation angle resolution

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 Maximum area in the workpiece appearance

Example) When the workpiece shape is cube

The workpiece appearance in the direction shown in the figure below is the maximum.



Viewpoint looking down from the camera side

Fig. 7-107 Example of the maximum area in the workpiece appearance

Note 4: Features of the main axis

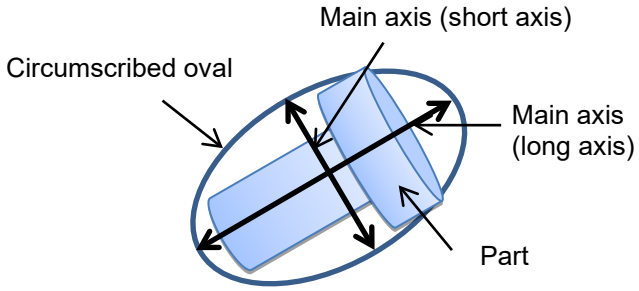


Fig. 7-108 Definition for the main axis feature mode

Start the automatic adjustment from the [Model-less Recognition Parameter Setting] screen.

(1) Click the [Automatic Setting] button in the job edit screen to display the Model-less Recognition Parameter Setting screen.
(2) Press the [Automatic Setting] button.
(3) The following caution window appears. Click [OK] to display the Automatic adjustment screen.

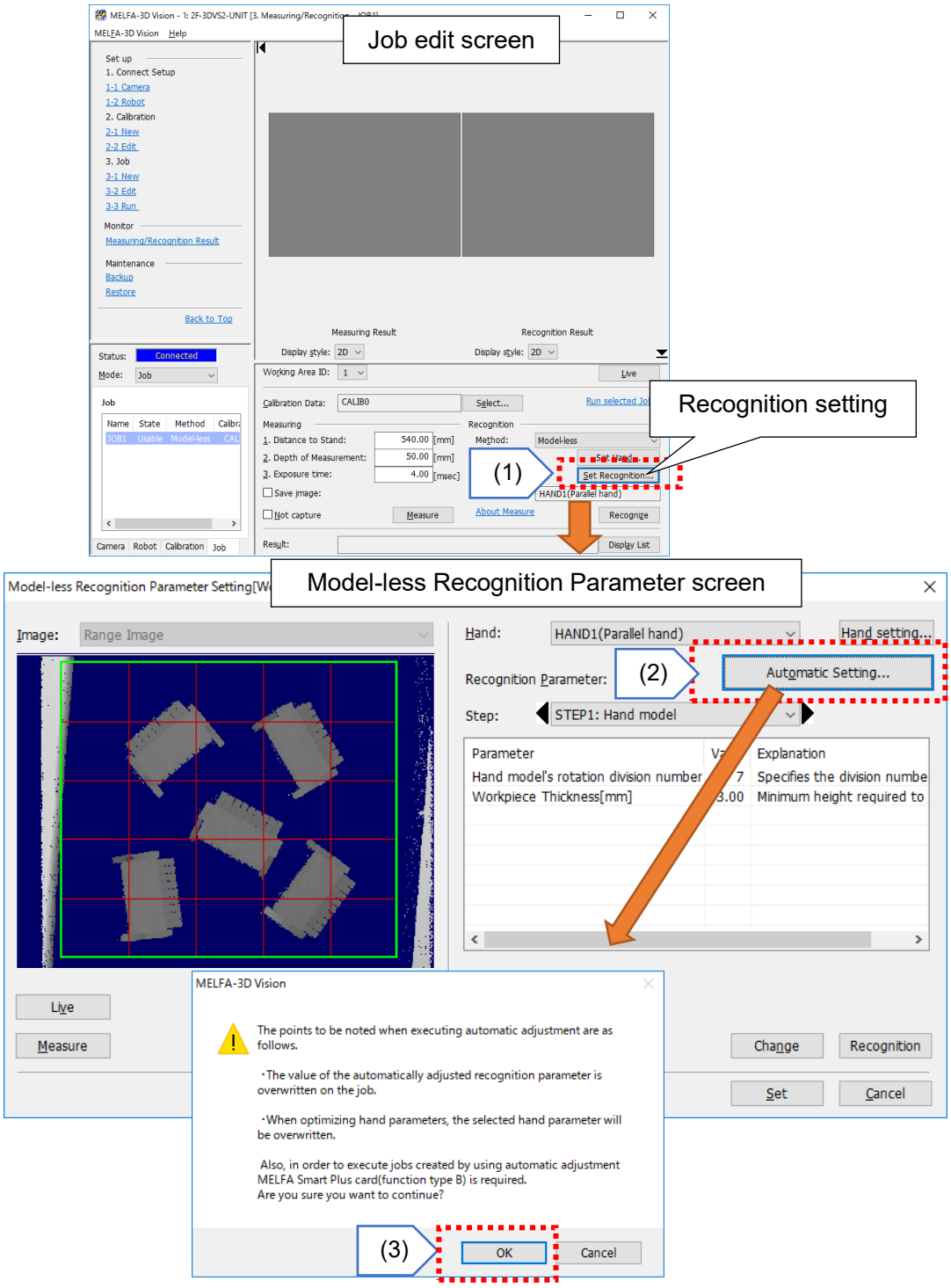


Fig. 7-109 Model-less Recognition Parameter screen

(4)-1 Preparing and registering the workpiece model

First, register the workpiece model for which the automatic adjustment is executed.
(If you do not have a workpiece model, you can create a workpiece model file using the layout tool of RT ToolBox3.)

(1) Click the [Select] button and select the corresponding workpiece model. The applicable model type is STL, OBJ, PLY, and VRML (except for the models that including RGB channel).
(2) The image of the selected workpiece model is displayed in the screen.

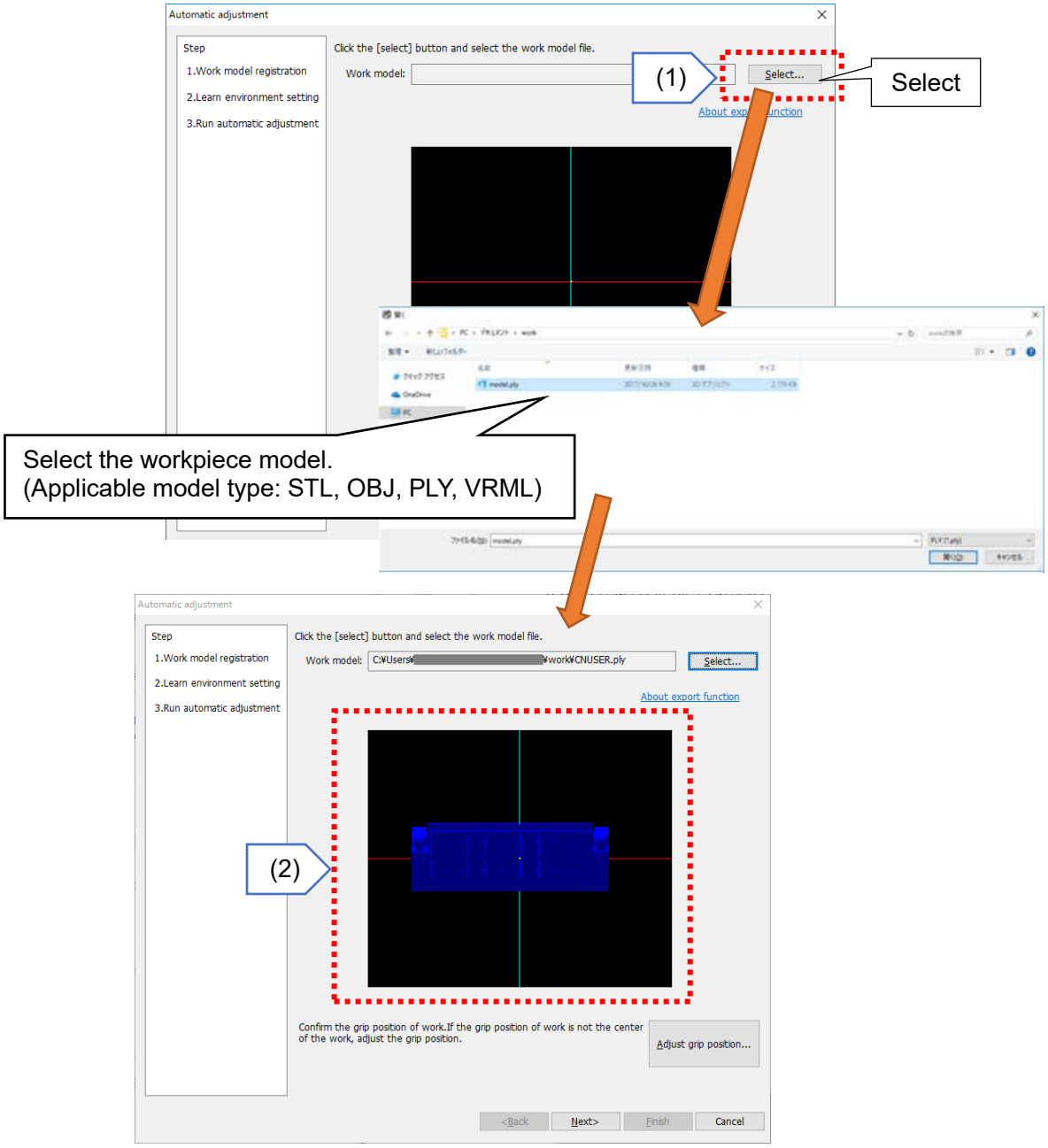
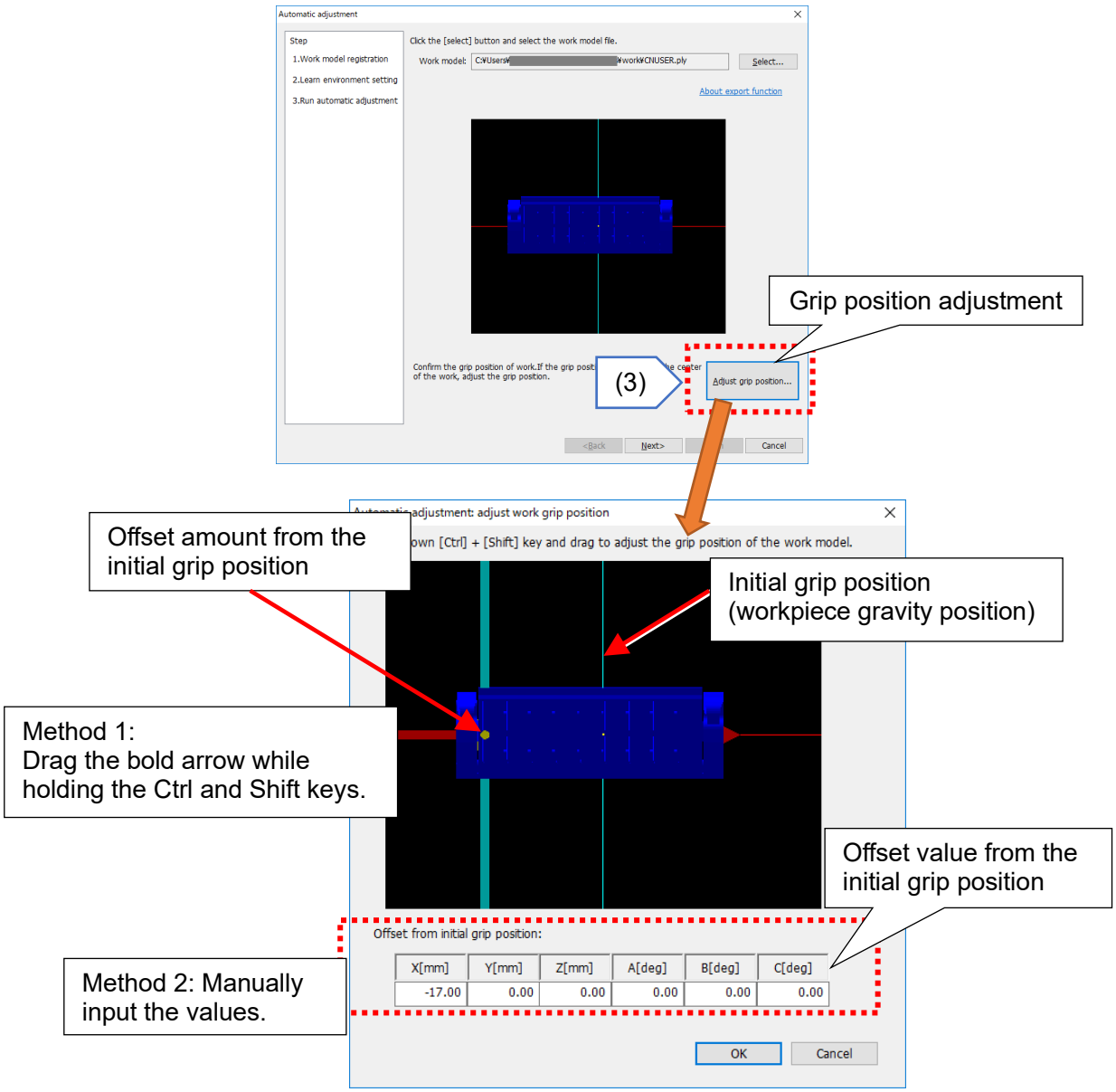


Fig. 7-110 Preparing and registering the workpiece model 1

(3) Adjust the grip position of the selected workpiece model. Click the [Adjust grip position] button.
(4) Click the [OK] button after the adjustment.



<Adjustment method of the workpiece model grip position>

Method 1: Drag the bold arrow while holding the Ctrl and Shift keys to adjust the offset amount from the initial grip position.

Method 2: Manually input the offset values from the initial grip position. The bold arrow indicating the offset from the initial grip position displayed in the window moves by the input values.

・The initial grip position of the workpiece model is indicated by the thin grid line, the offset value from the initial grip position is indicated by the bold arrow.

・As the initial grip position and offset position is the same, the thin grid line and bold arrow are displayed at the same position.

・The workpiece gravity position is used as the initial grip position.

Fig. 7-111 Preparing and registering the workpiece model 2

(5) The preparation and registration of the workpiece model is completed.
Click the [Next] button to proceed to the learn environment parameter setting.

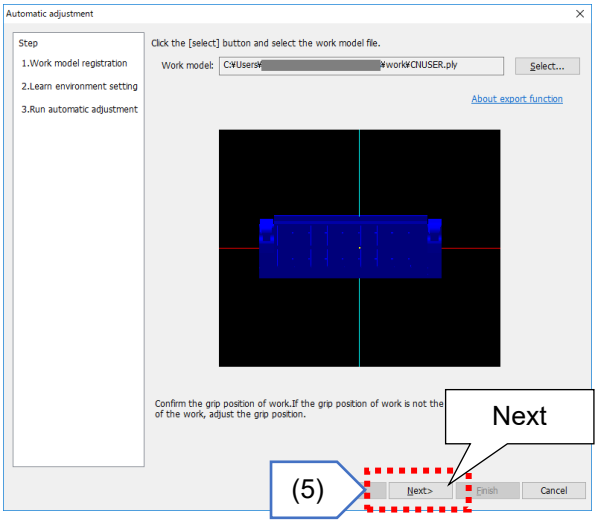


Fig. 7-112 Preparing and registering the workpiece model 3

(4)-2 Setting the learning environment parameters

The window displayed for the learn environment parameter setting differs depending on the hand type selected in the hand settings of the job.
As the hand parameters are automatically adjusted in the recognition processing, design the actual hand according to the physical environment (workpiece weight and material).

Types of the window to be displayed

Pattern	Hand type	Description
1	Suction hand	Circular suction pad (The pad diameters in the Xt axis direction and the Yt axis direction are the same.)
2	Suction hand	Oval suction pad (The pad diameters in the Xt axis direction and the Yt axis direction differ.)
3	Tweezers hand	For tweezers hand (3 claws, 4 claws) Adjust the diameter between the claws.
4	Parallel gripping hand	Adjust the hand open width and claw interference range.
5	Internal gripping tweezers hand	For internal gripping tweezers hand (2 claws, 3 claws)
6	Other than the above	

The window to be displayed is explained by using pattern 4 (parallel gripping hand) as an example.
(The windows for other patterns are shown in the following pages.)

■Pattern 4 (parallel gripping hand)

The parallel gripping hand can optimize the hand open width based on the hand information set in "Specifying settings for the used hand". By setting the search range (Xt axis direction and Yt axis direction) in this window, the claw interference range can be optimized.

(1) To optimize the hand open width, select [Optimize hand open width].

(2) To optimize the claw interference range, select [Optimize claw interference range] and input the search range (Xt axis direction and Yt axis direction).

(3) Input the number of workpieces and box size used for the bulk simulation.

(4) Click the [Confirm] button to update the distance image.

(5) Check the contents in the window and click [Next] button.

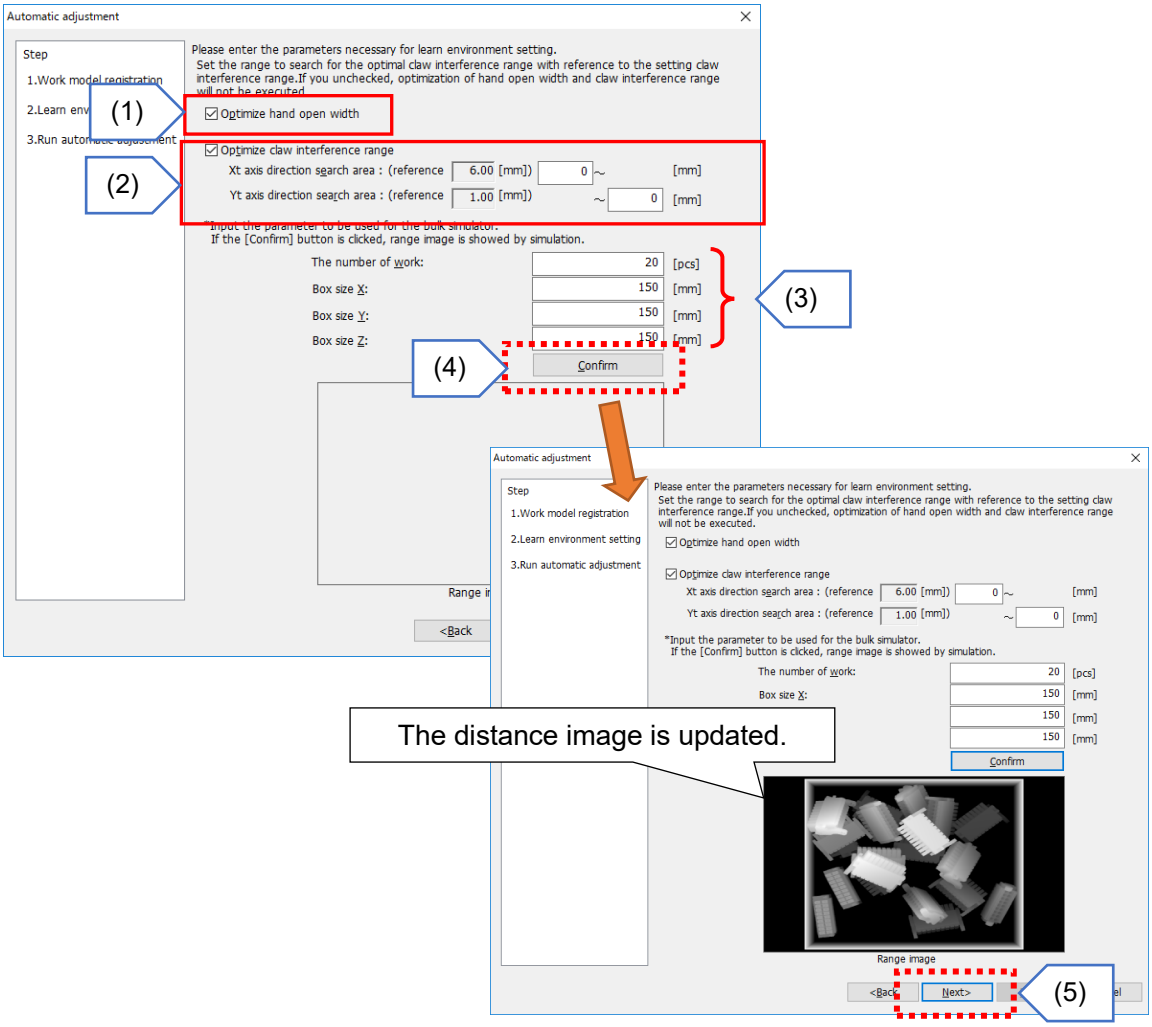
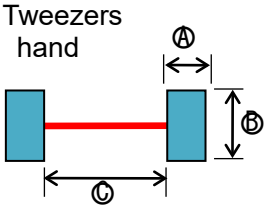


Fig. 7-113 Window for pattern 5 (parallel gripping hand)

Parameters of the parallel gripping hand that can be optimized

Hand type	Parameter	Unit	Description	Range	Default setting
Tweezers hand 	Claw interference diameter Ⓐ (Yt-axis direction)	mm	Yt-axis direction diameter in hand coordinate system	0.5 to 100	1
	Claw interference diameter Ⓑ (Xt-axis direction)	mm	Xt-axis direction diameter 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

■Pattern 1 (suction hand and circular suction pad)

When the suction pad is circular (when the pad diameters in the Xt axis direction and the Yt axis direction are the same), the pad diameters can be optimized by setting the search range.

(1) To optimize the suction pad diameter, select [Optimize diameter] and input the search range.
(2) Input the number of workpieces and box size used for the bulk simulation.
(3) Click the [Confirm] button to update the distance image.
(4) Check the contents in the window and click [Next] button.

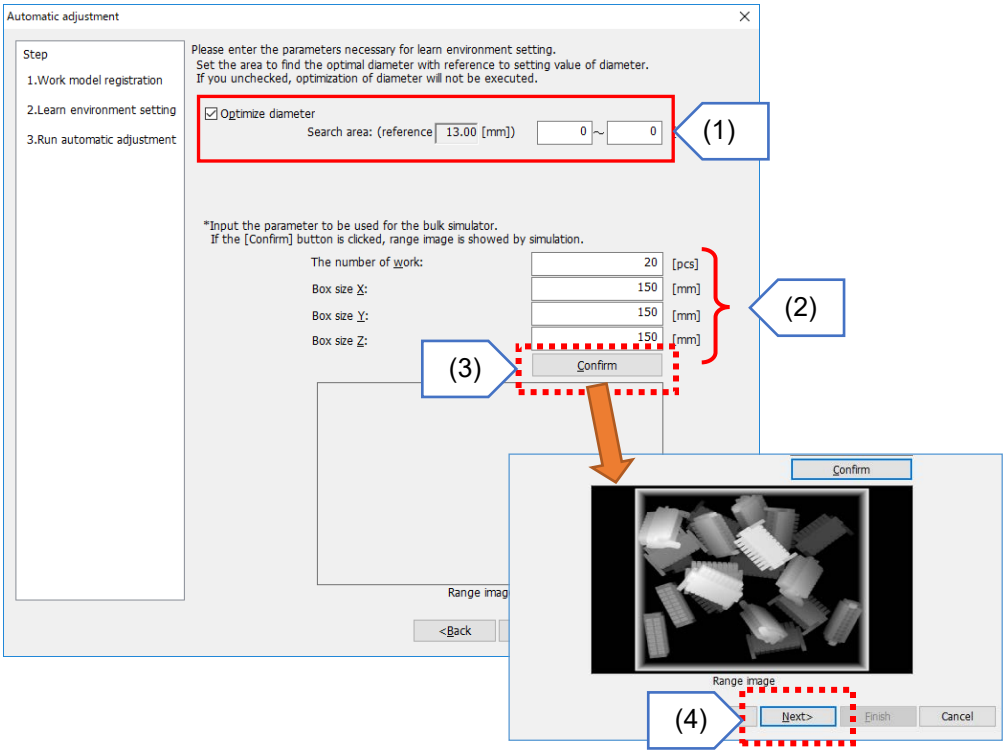
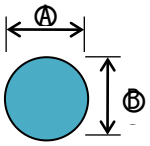


Fig. 7-114 Window for pattern 1 (suction hand and circular suction pad)

Parameters of the suction hand (circular suction pad) that can be optimized

Hand type	Parameter	Unit	Description	Range	Default setting
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

■Pattern 2 (suction hand and oval suction pad)

When the suction pad is oval (when the pad diameters in the Xt axis direction and the Yt axis direction differ), the pad diameters can be optimized by setting the search range.

(1) To optimize the suction pad diameter, select [Optimize diameter] and input the search range (Xt axis direction and Yt axis direction).

(2) T Input the number of workpieces and box size used for the bulk simulation.

(3) Click the [Confirm] button to update the distance image.

(4) Check the contents in the window and click [Next] button.

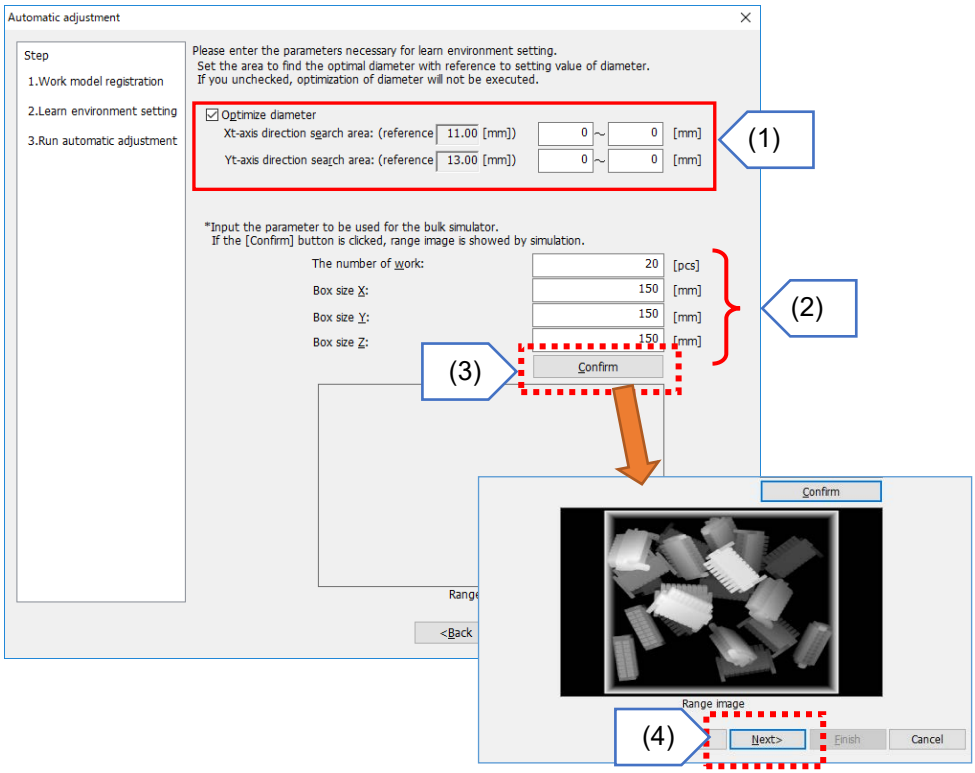
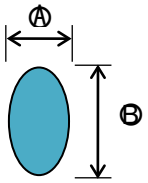


Fig. 7-115 Window for pattern 2 (suction hand and oval suction pad)

Parameters of the suction hand (oval suction pad) that can be optimized

Hand type	Parameter	Unit	Description	Range	Default setting
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

■Pattern 3 (tweezers hand/3 claws, 4 claws)

For the tweezers hand (3 claws, 4 claws), the diameter between claws can be optimized.

(1) Select [Optimize diameter] to optimize the diameter between claws.
(2) Input the number of workpieces and box size used for the bulk simulation.
(3) Click the [Confirm] button to update the distance image.
(4) Check the contents in the window and click [Next] button.

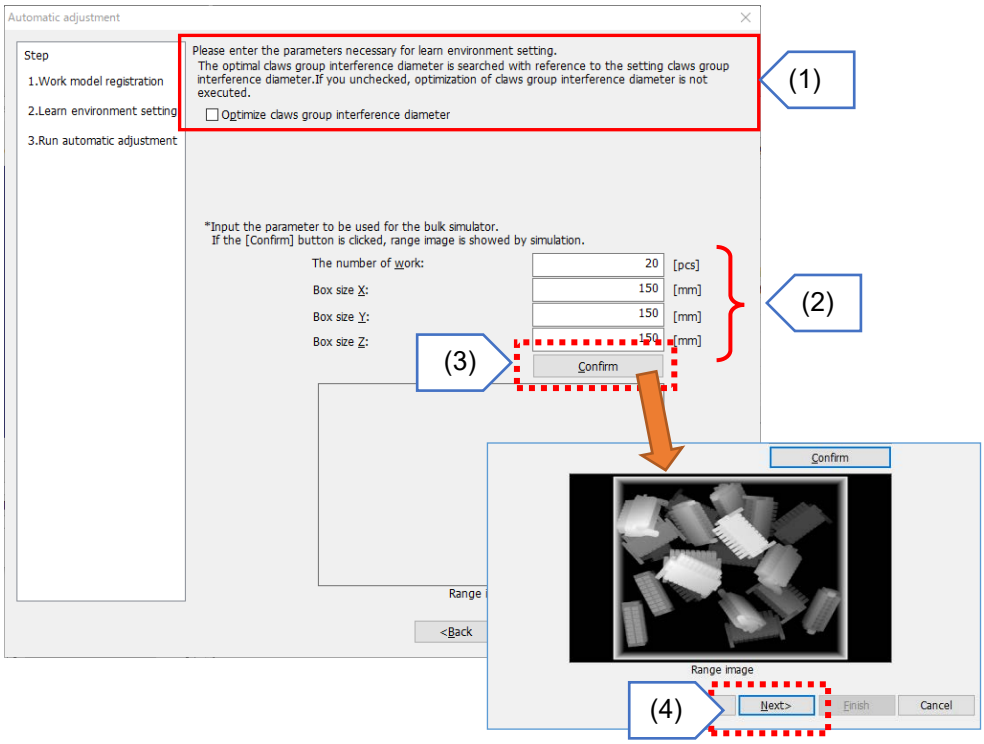
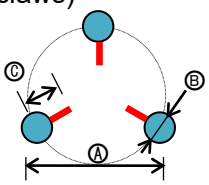
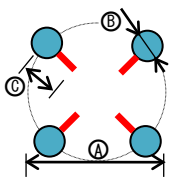


Fig. 7-116 Window for pattern 4 (tweezers hand)

Parameters of the suction hand (tweezers hand and oval suction pad) that can be optimized

Hand type	Parameter	Unit	Description	Range	Default setting
Tweezers hand (3 claws) 	Claws group interference diameter Ⓐ	mm	Diameter of interference area consists of claws when hand open	0.5 to 200	10
Tweezers hand (4 claws) 	Claws group interference diameter Ⓐ	mm	Diameter of interference area consists of claws when hand open	0.5 to 200	10

■Pattern 5 (internal gripping tweezers hand/2 claws, 3 claws)

For the internal gripping tweezers hand (2 claws, 3 claws), optimize the hand open width.

(1) Input the number of workpieces and box size used for the bulk simulation.

(2) Click the [Confirm] button to update the distance image.

(3) Check the contents in the window and click [Next] button.

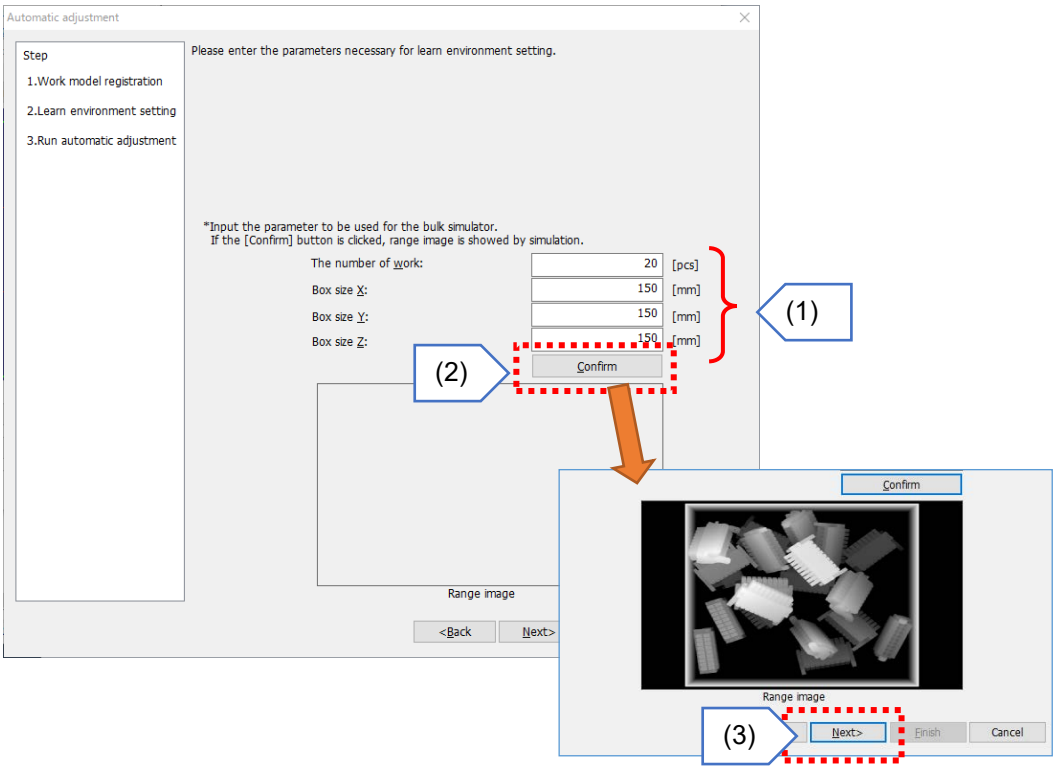
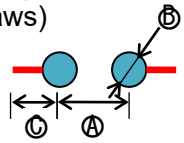
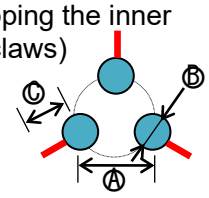


Fig. 7-117 Window for pattern 6 (internal gripping tweezers hand/2 claws, 3 claws)

Parameters of the internal gripping tweezers hand (2 claws, 3 claws) that can be optimized

Hand type	Parameter	Unit	Description	Range	Default setting
weezers hand gripping the inner (2 claws) 	Hand open width Ⓒ	mm	Claw center point distance when hand open	0.5 to 100	5
Tweezers hand gripping the inner (3 claws) 	Hand open width Ⓒ	mm	Claw center point distance when hand open	0.5 to 100	5

■Pattern 6 (hand other than pattern 1 to 5)

For the hand other than pattern 1 to 5 in the previous page, the hand open width can be optimized.

(1) To optimize the hand open width, select [Optimize hand open width].

(2) Input the number of workpieces and box size used for the bulk simulation.

(3) Click the [Confirm] button to update the distance image.

(4) Check the contents in the window and click [Next] button.

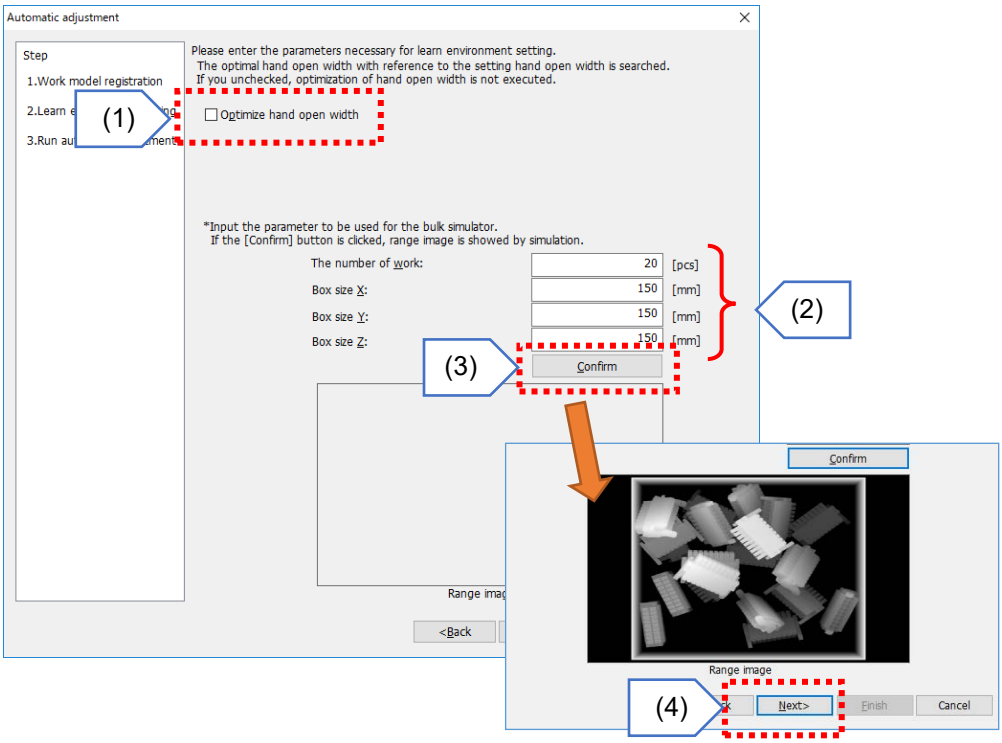
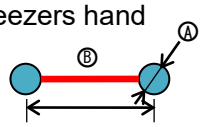
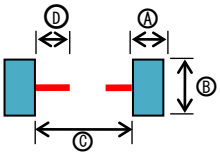
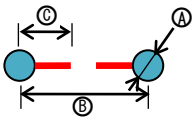


Fig. 7-118 Window for pattern 3 (hand other than pattern 1, 2, 4, 5, and 6)

Parameters for the hand other than pattern 1 to 5 that can be optimized

Hand type	Parameter	Unit	Description	Range	Default setting
Tweezers hand 	Hand open width Ⓑ	mm	Claw center point distance when hand open	0.5 to 200	5
Parallel hand (Limited stroke) 	Hand open width Ⓒ	mm	Claw inner side distance when hand open	0.5 to 200	5
Tweezers hand (Limited stroke) 	Hand open width Ⓑ	mm	Claw center point distance when hand open	0.5 to 200	5

(4)-3 Executing the automatic adjustment

(1) Click the [Run] button in the Automatic adjustment screen after setting the learn environment parameters.
(2) A confirmation window appears. Click [OK] to execute automatic adjustment.
(3) The progress rate and recognition image are displayed in the recognition parameter adjusting window.
(4) When the automatic adjustment of the recognition parameter is completed, a completion message appears. Click the [OK] button in the message window and then click the [Finish] button in the Automatic adjustment screen. The Automatic adjustment screen closes and the parameter of the job is overwritten.

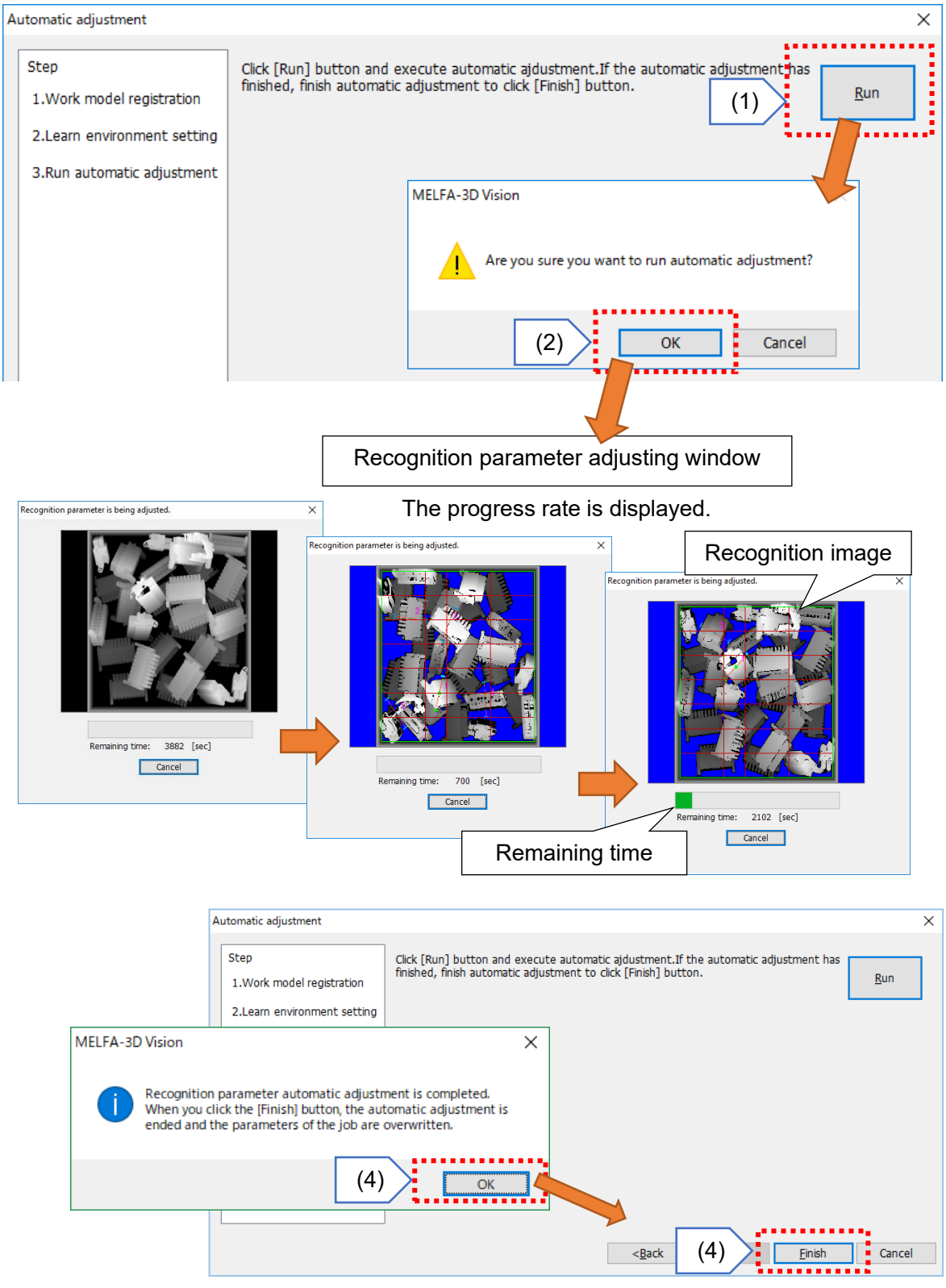


Fig. 7-119 Executing the automatic adjustment

(4)-4 Actual environment adaptive parameter

Adjust the following parameter at step 2 in the Model-less Recognition Parameter Setting screen according to the customer's actual environment.

Floor height
Recognition range: X start point/X finish point/Y start point/Y finish point
Number of recognition area divisions: Horizontal/Vertical

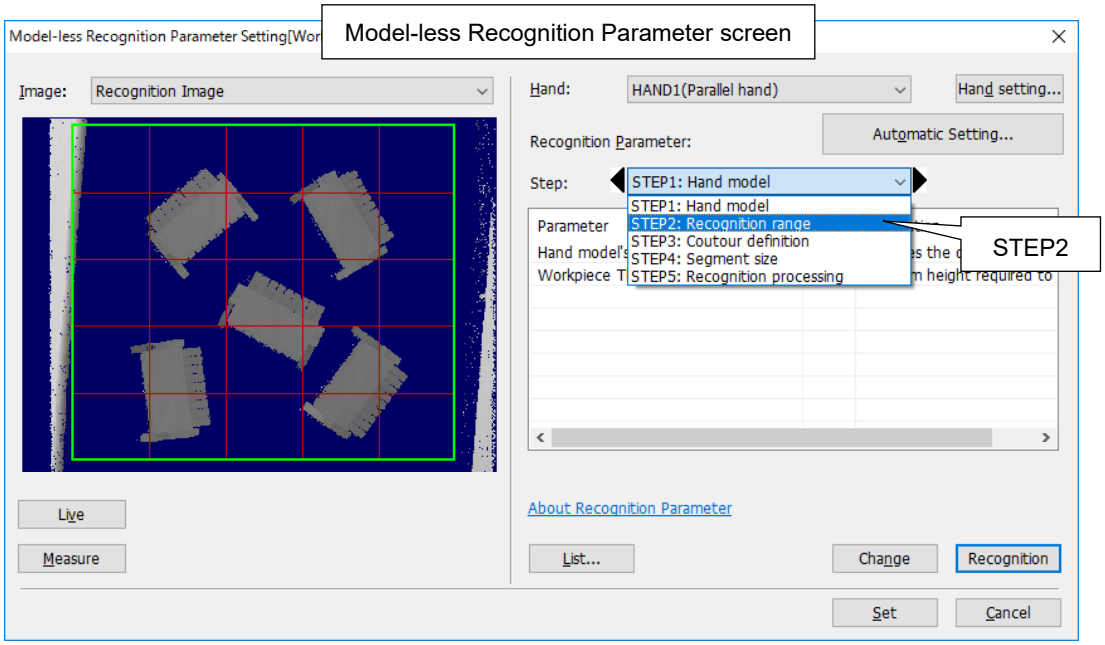
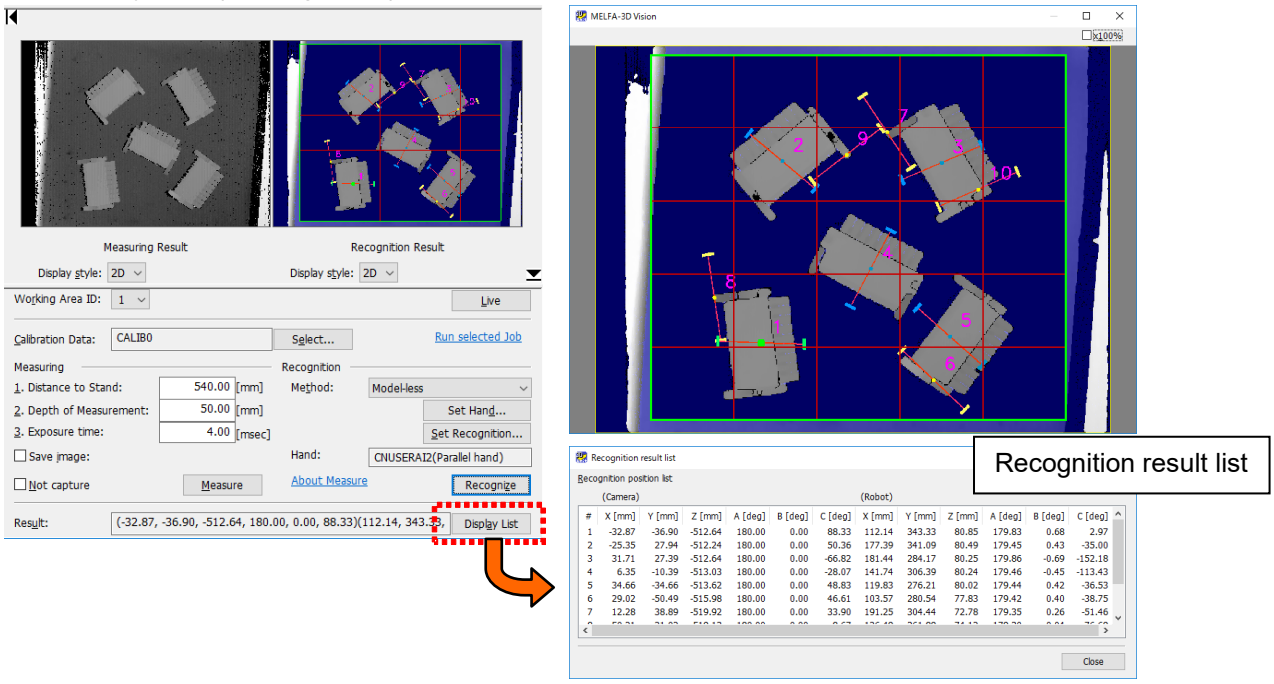


Fig. 7-120 Actual environment adaptive parameter

(5) 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. 3-14).



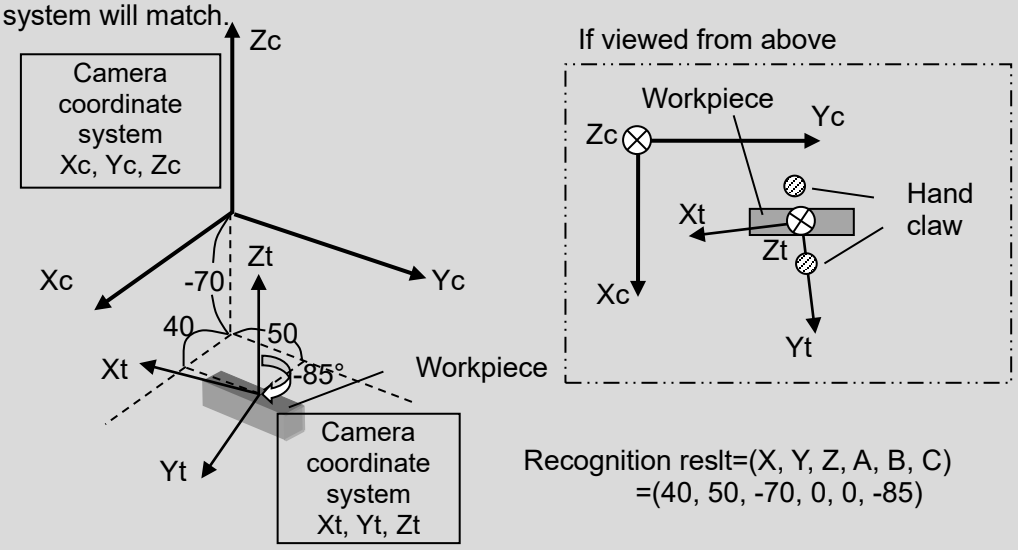
Recognition result list

* For the camera coordinates, refer to "3.4.4 Camera coordinate system". For the robot coordinates, refer to the instruction manual "Detailed explanations of functions and operations".

Fig. 7-121 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.

7.12.3.2. 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. 7-122. By calculating the grip position from the recognition position using the correction vector, workpieces can be gripped.

***Model matching recognition is available only for RV series.**

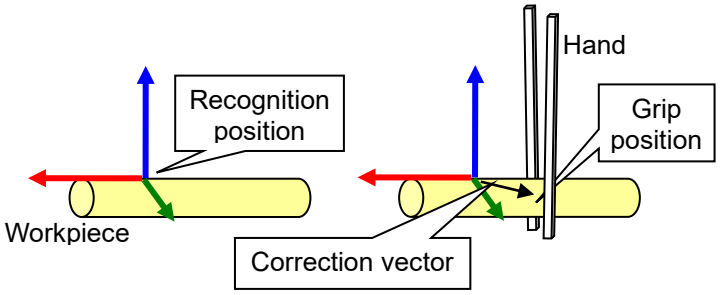


Fig. 7-122 Difference between recognition position and grip position

(1) 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 ToolBox3, 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.

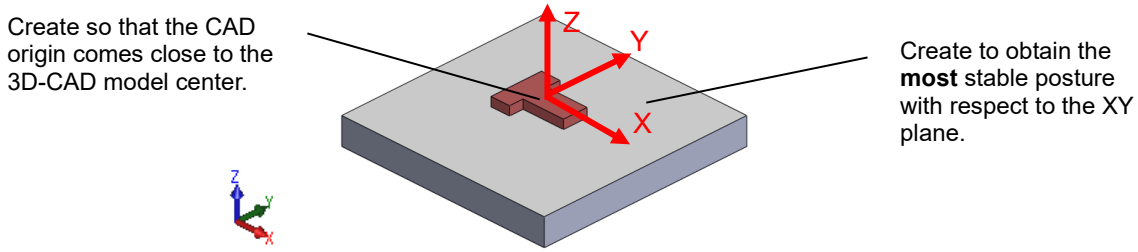


Fig. 7-123 3D-CAD model creation example

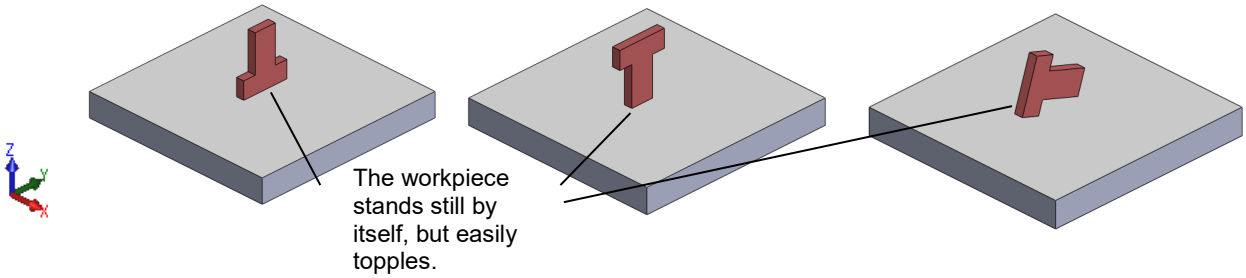


Fig. 7-124 Example of other unstable postures

(2) Selecting the recognition method

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

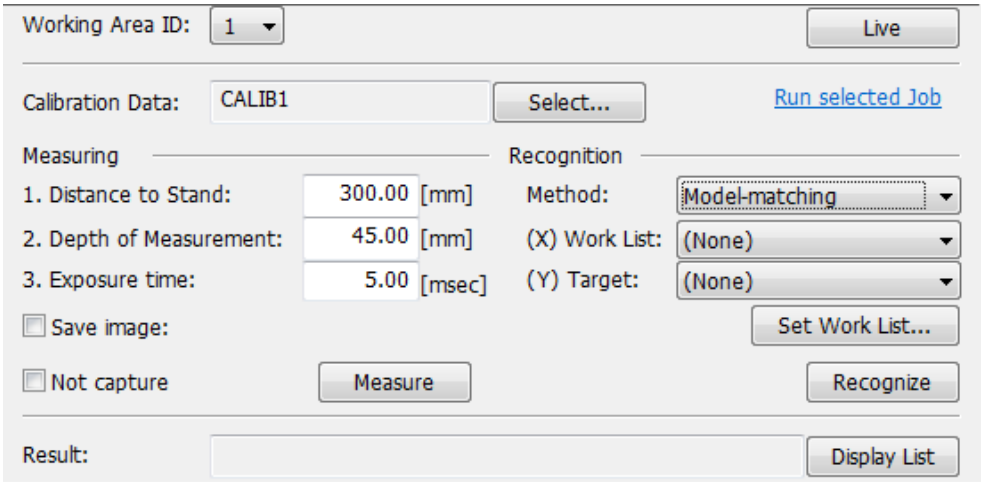
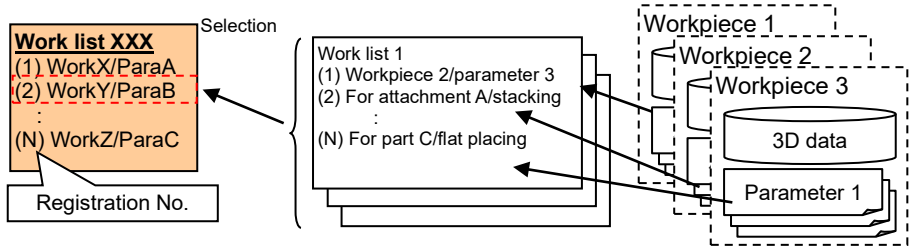


Fig. 7-125 Selection of the recognition method (model matching recognition)

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

Table 7-28: 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

(3) 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.

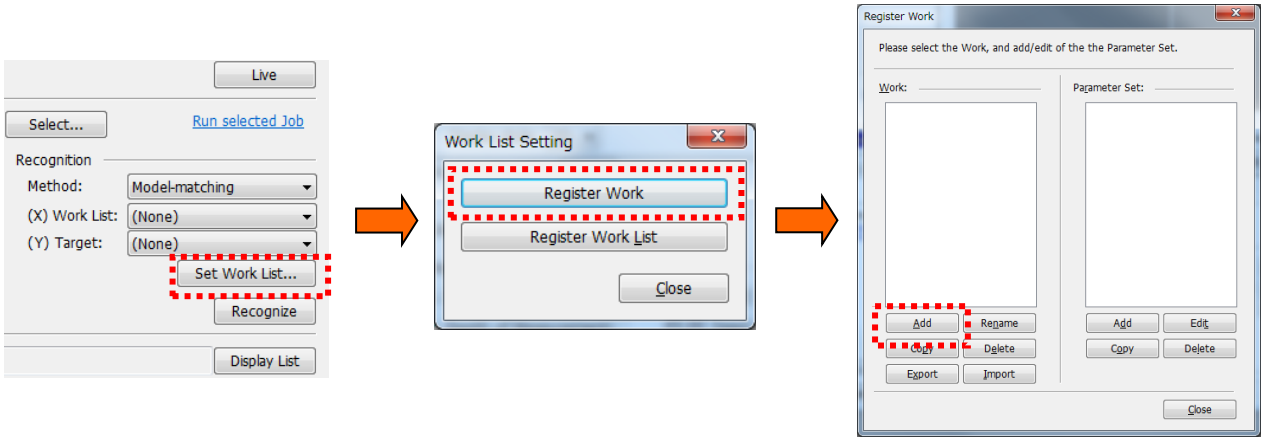


Fig. 7-126 Workpiece list settings and workpiece registration

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.

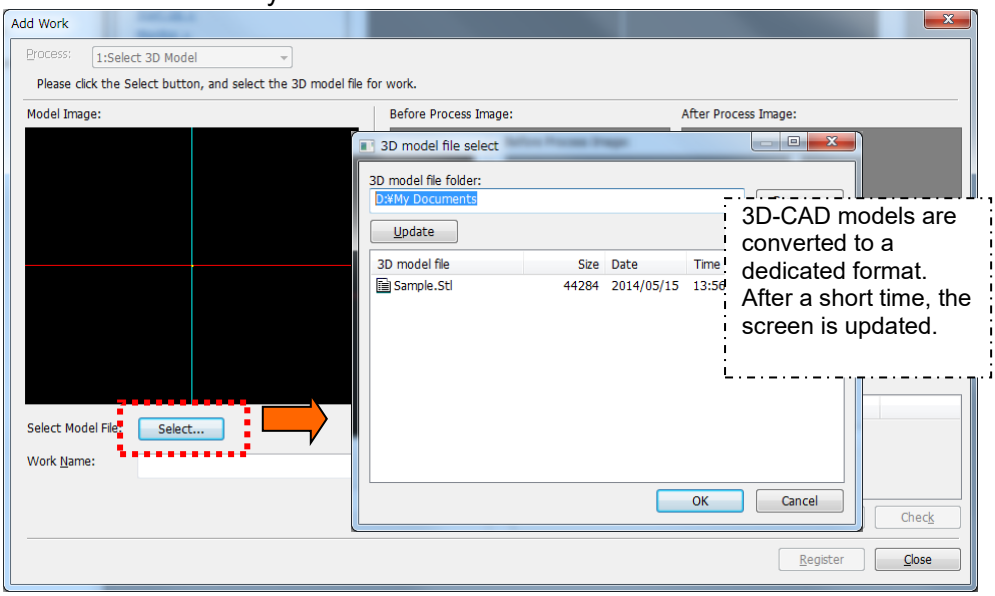


Fig. 7-127 Workpiece addition

(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.

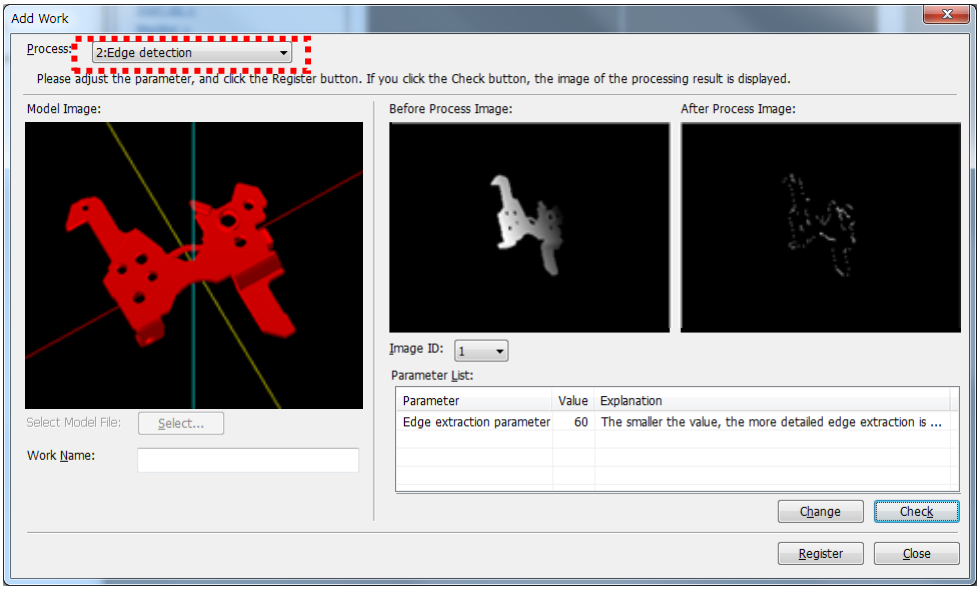


Fig. 7-128 Edge detection

Table 7-29: 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.

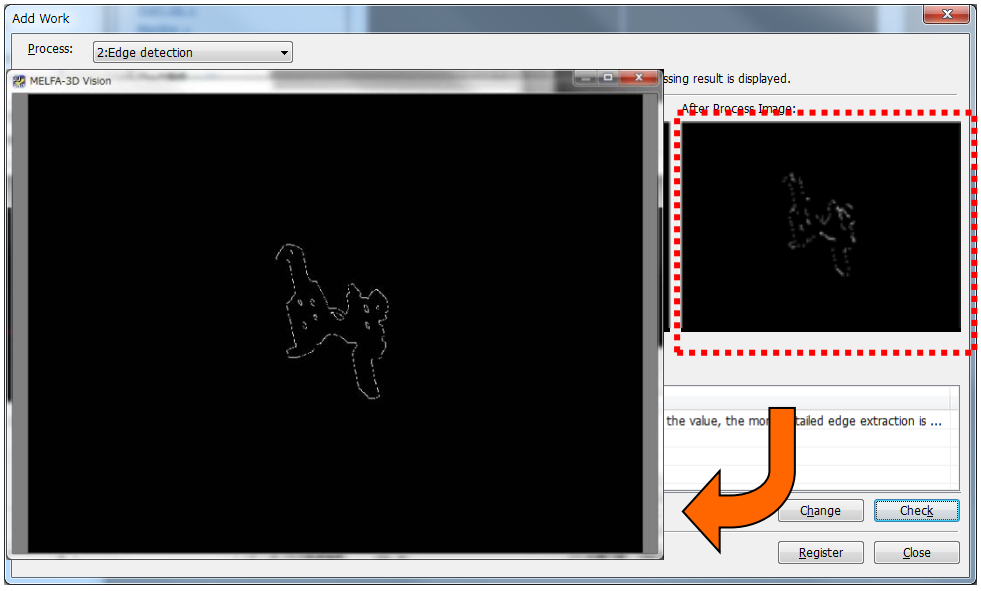


Fig. 7-129 Enlarged image

Check the enlarged image screen for the image after processing to ensure that edges are detected as described in Table 7-30.

Table 7-30: 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.

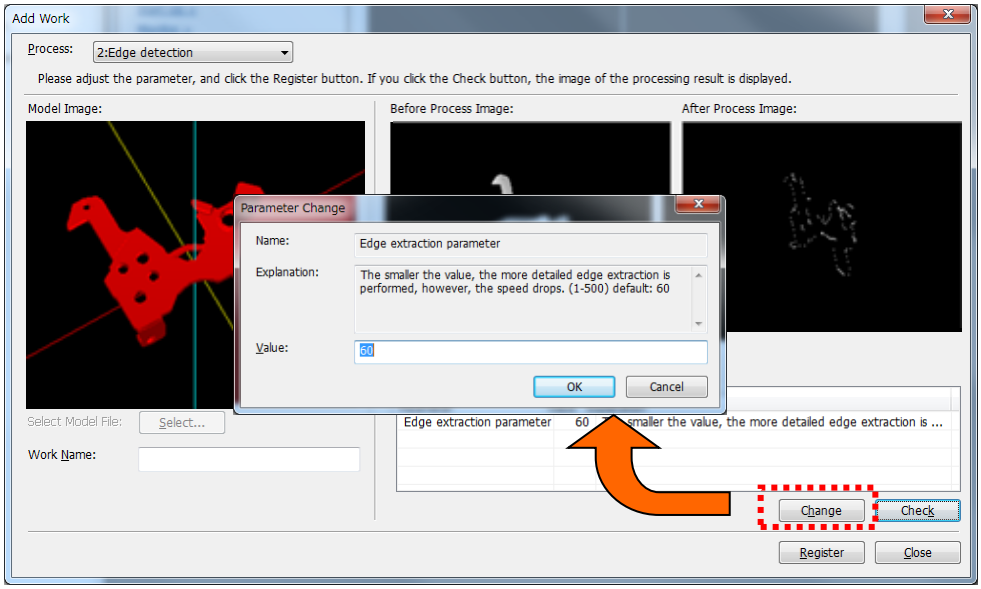


Fig. 7-130 Parameter change

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 7-30 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.

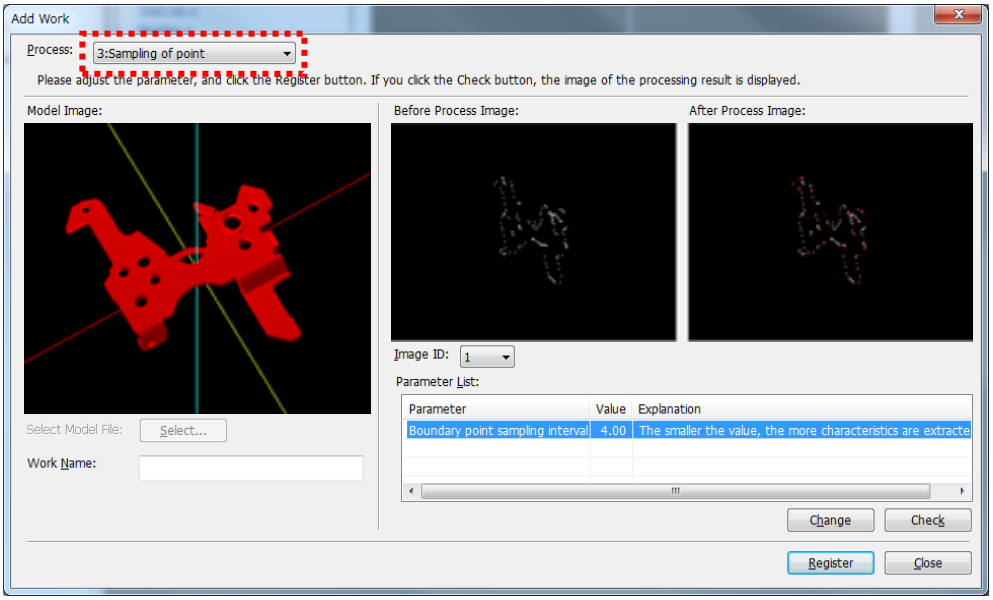


Fig. 7-131 Sampling of point

Table 7-31 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.

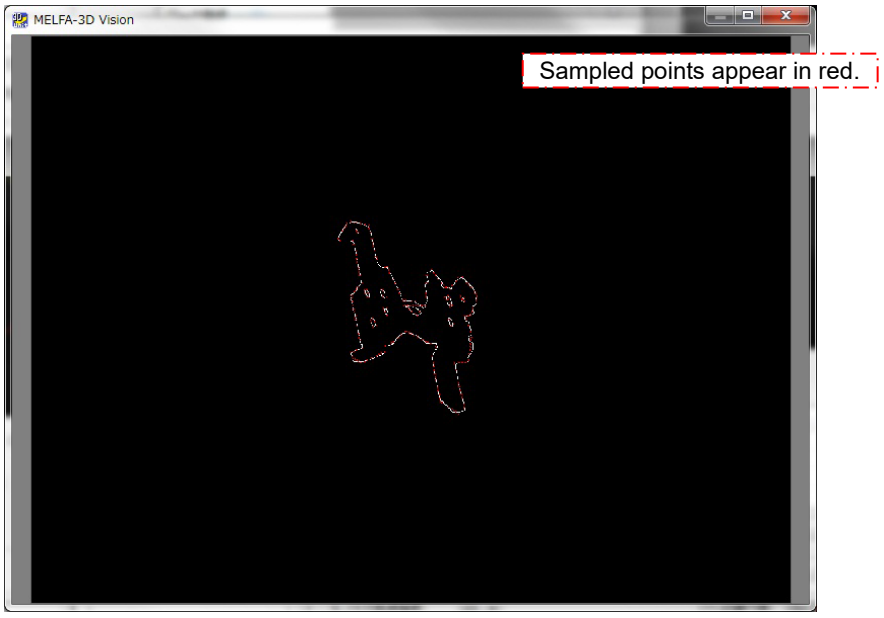


Fig. 7-132 Successful example for sampling of point

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.

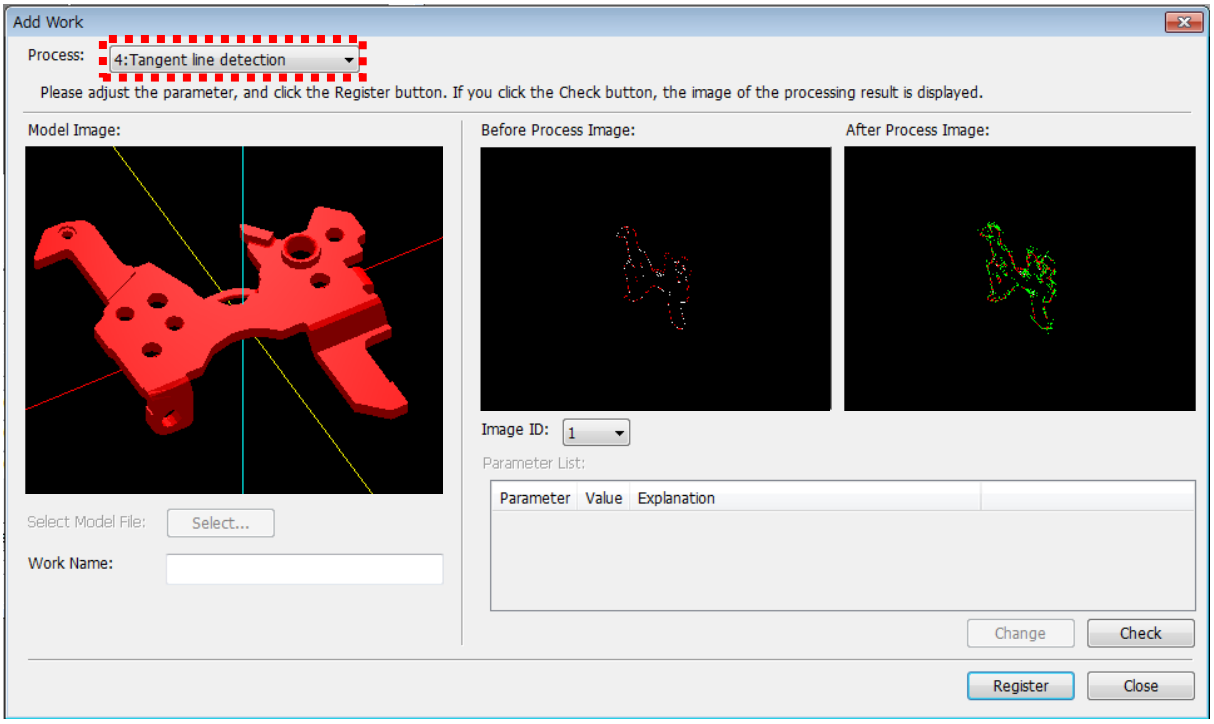


Fig. 7-133 Tangent line detection

Check the enlarged image screen for the image after processing to ensure that straight lines are detected as in Fig. 7-134.

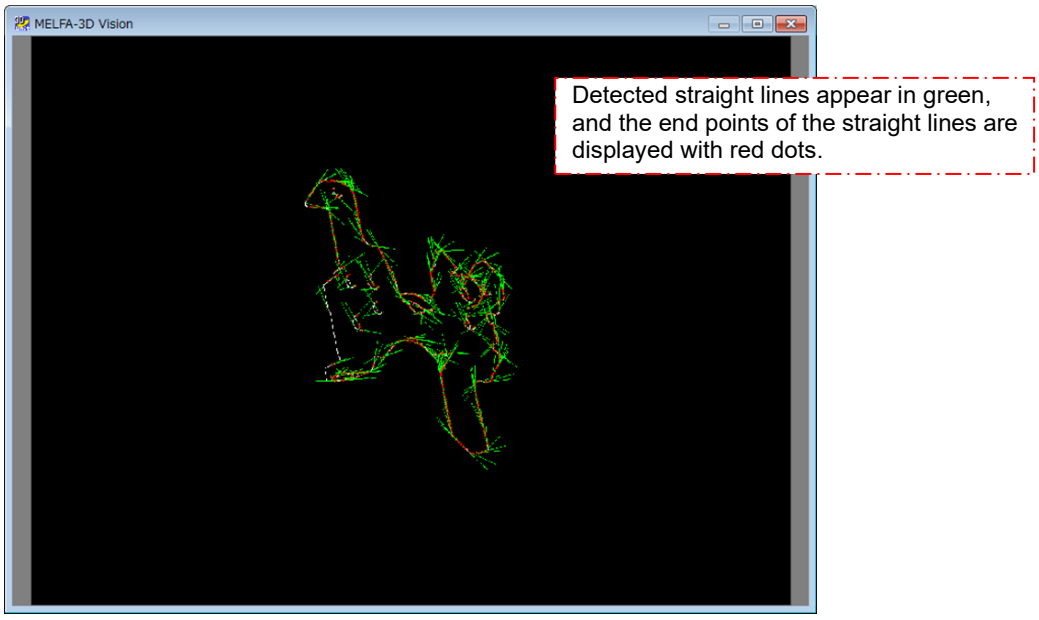


Fig. 7-134 Straight line successful example

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

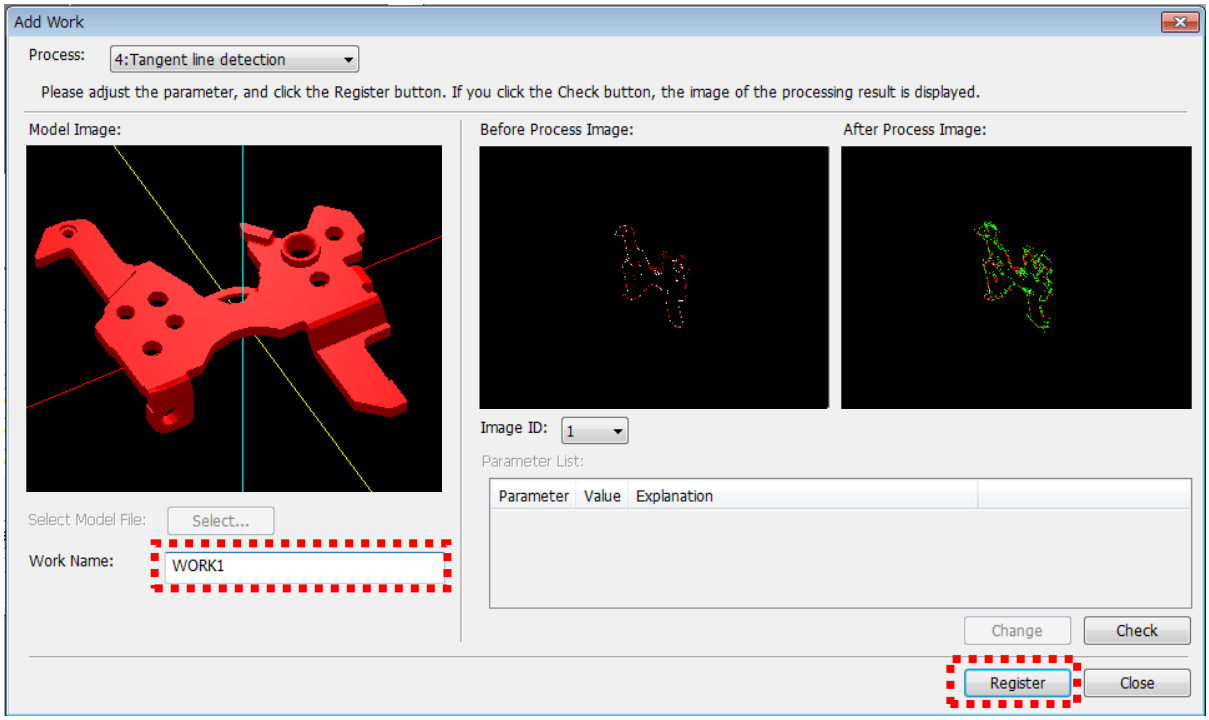


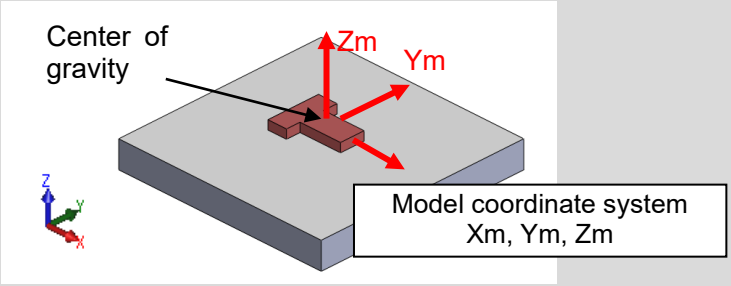
Fig. 7-135 Registration of workpiece

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.

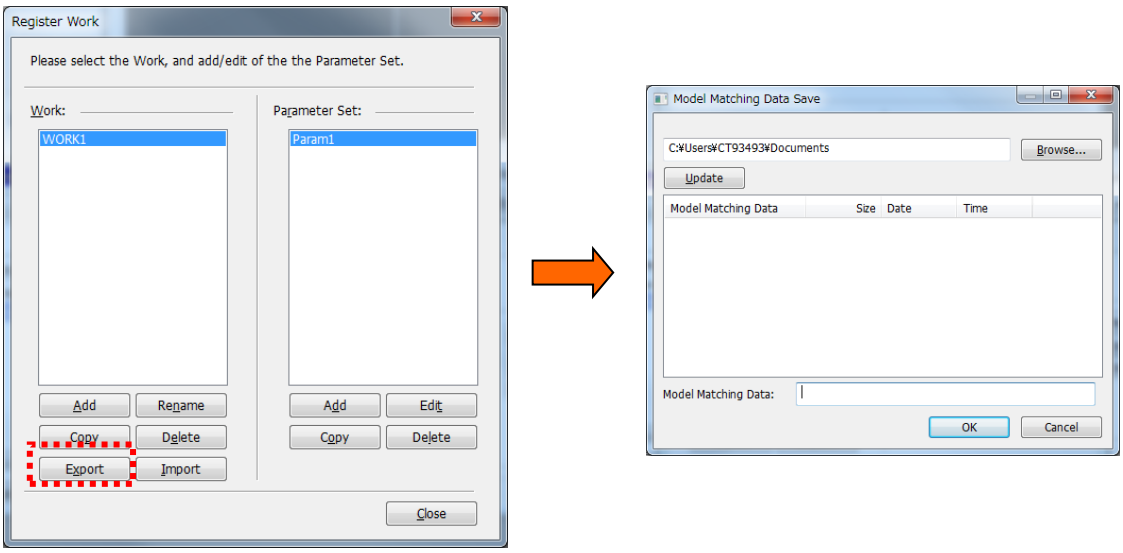


Fig. 7-136 Parameter set editing

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

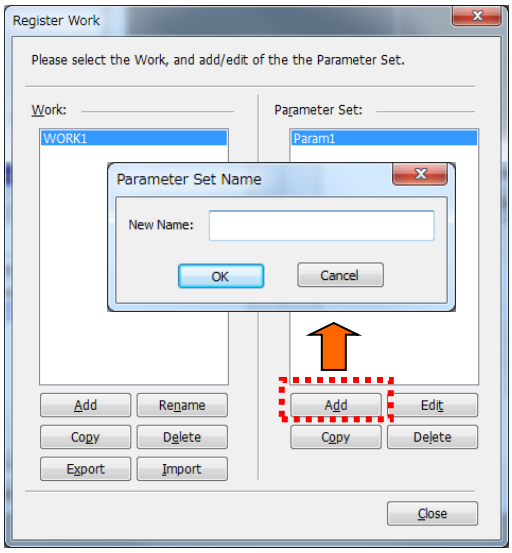


Fig. 7-137 Parameter set addition

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

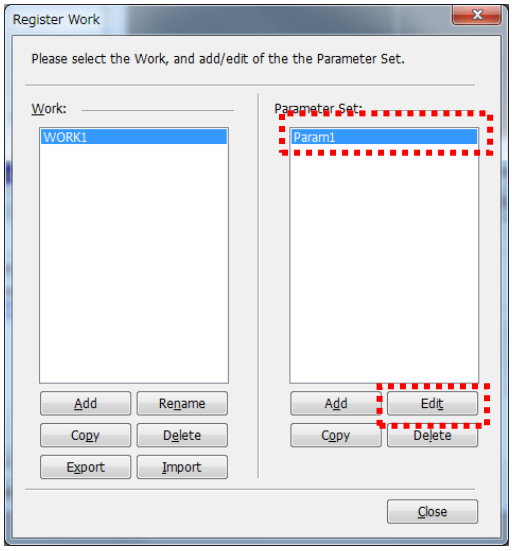


Fig. 7-138 Parameter set editing

(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.

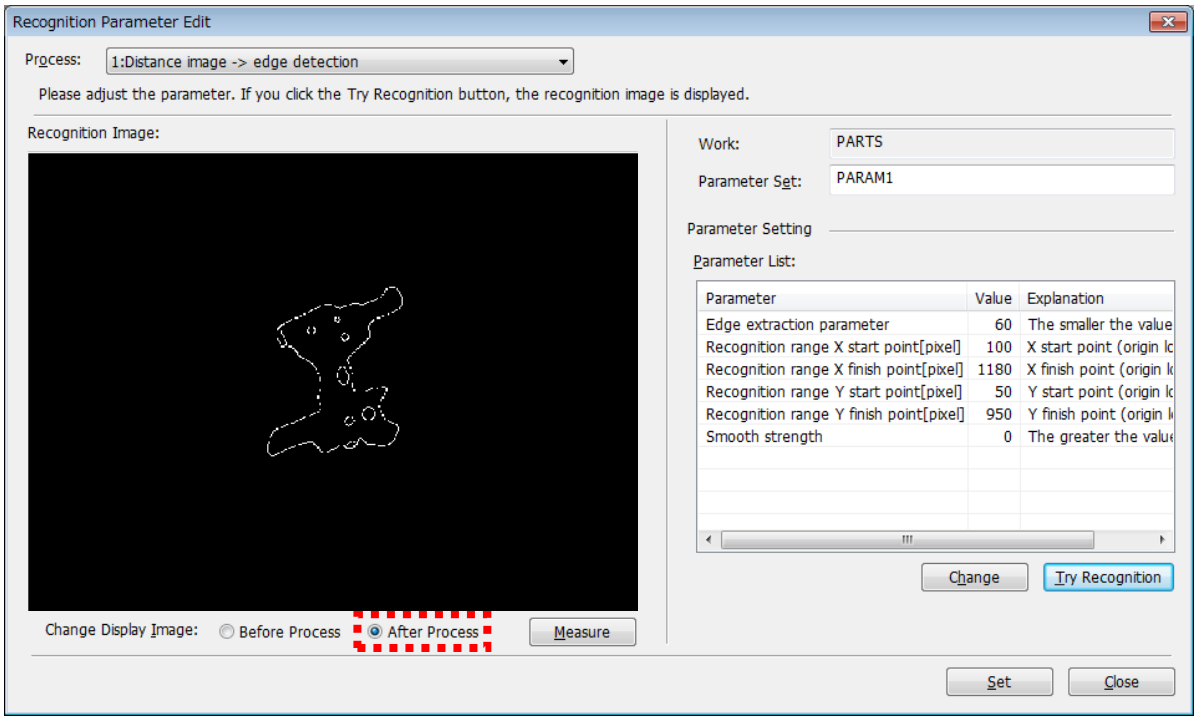


Fig. 7-139 Edge detection

Table 7-32: 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 1	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 1	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 1	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 1	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

Note 1: As the recognition range widens, the recognition time gets longer. Specify the range.
Upper left: Origin, Right direction: +X, Down direction: +Y.

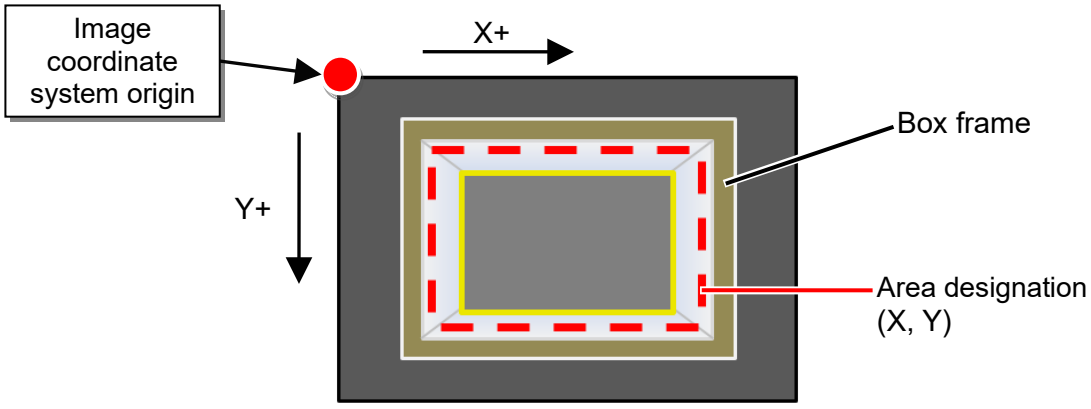


Fig. 7-140 Explanatory drawing for the recognition area

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.

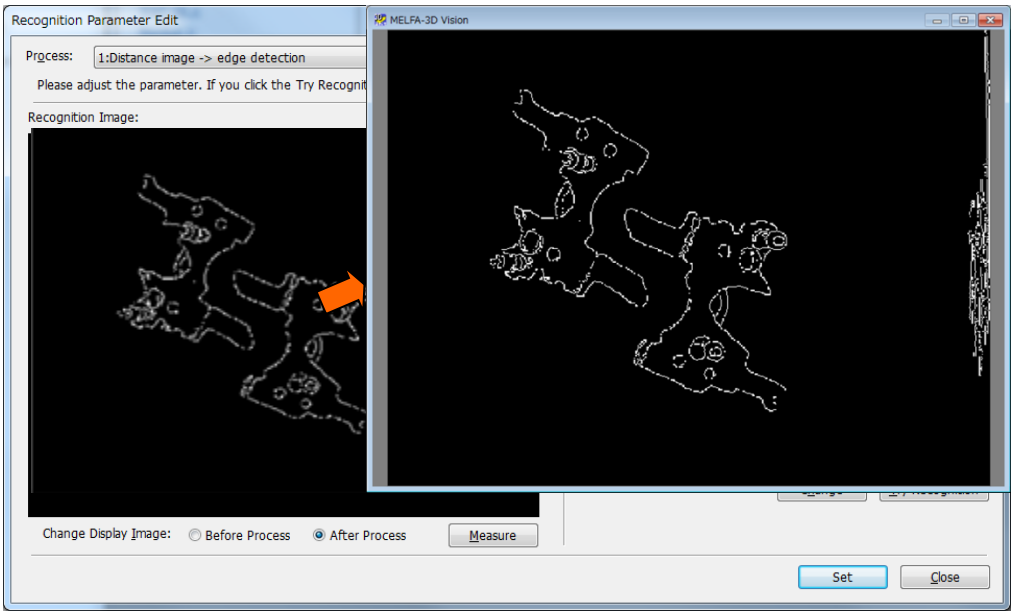


Fig. 7-141 Enlarged image

Check the enlarged image screen for the recognition image after processing to ensure that edges are detected as in Table 7-33.

Table 7-33: 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.

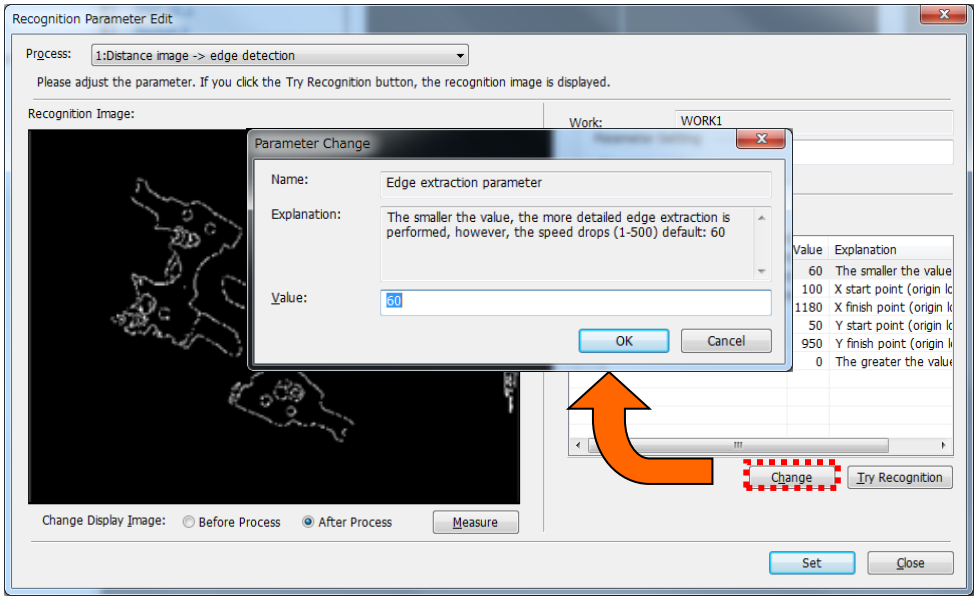


Fig.7-142 Recognition parameter change

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.

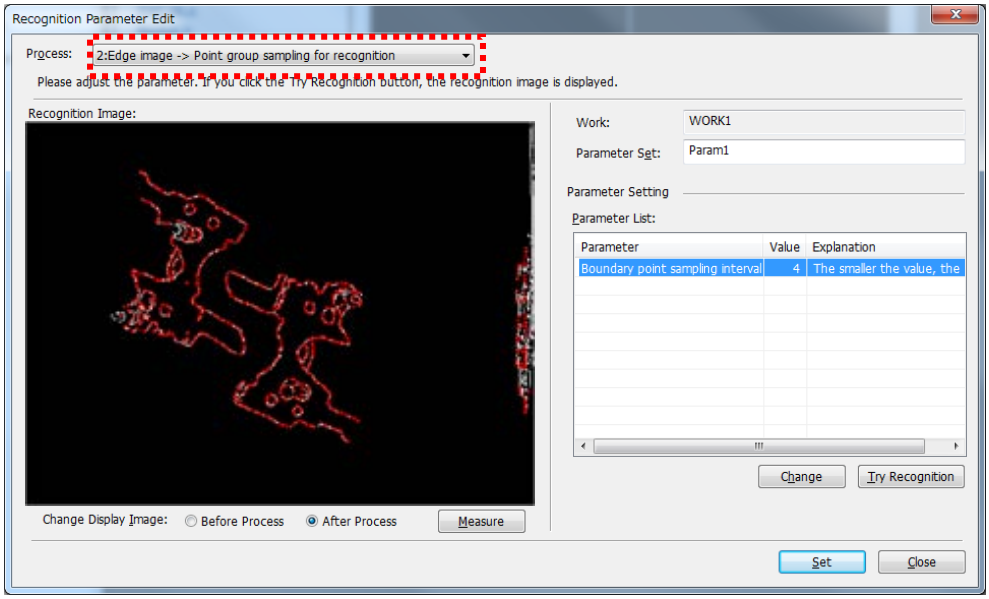


Fig. 7-143 Point group sampling for recognition

Table 7-34: 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.

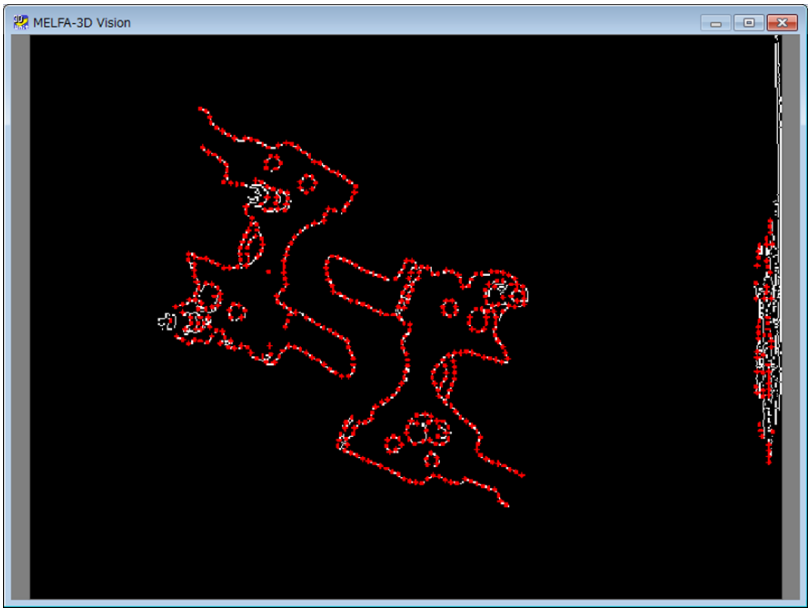


Fig. 7-144 Point sampling successful example

(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.

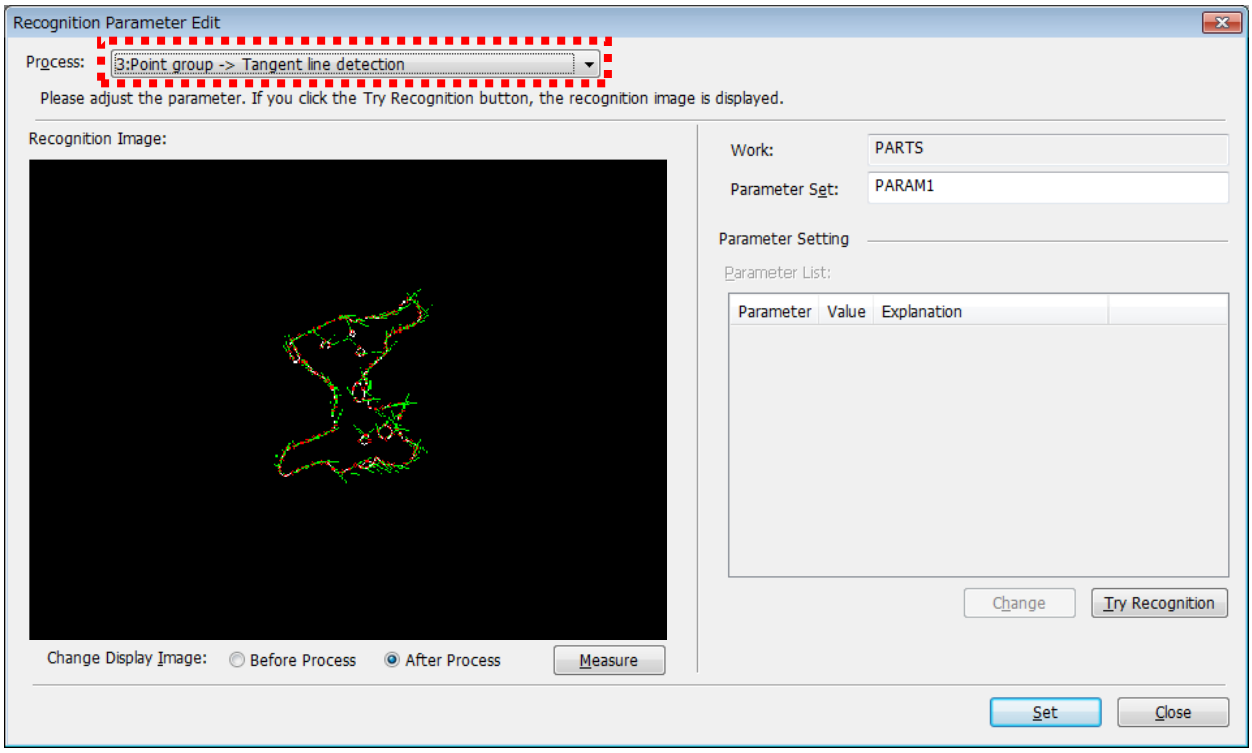


Fig. 7-145 Tangent line detection

While displaying the enlarged image screen of the recognition image, confirm that a straight line is detected as in Table 7-35.

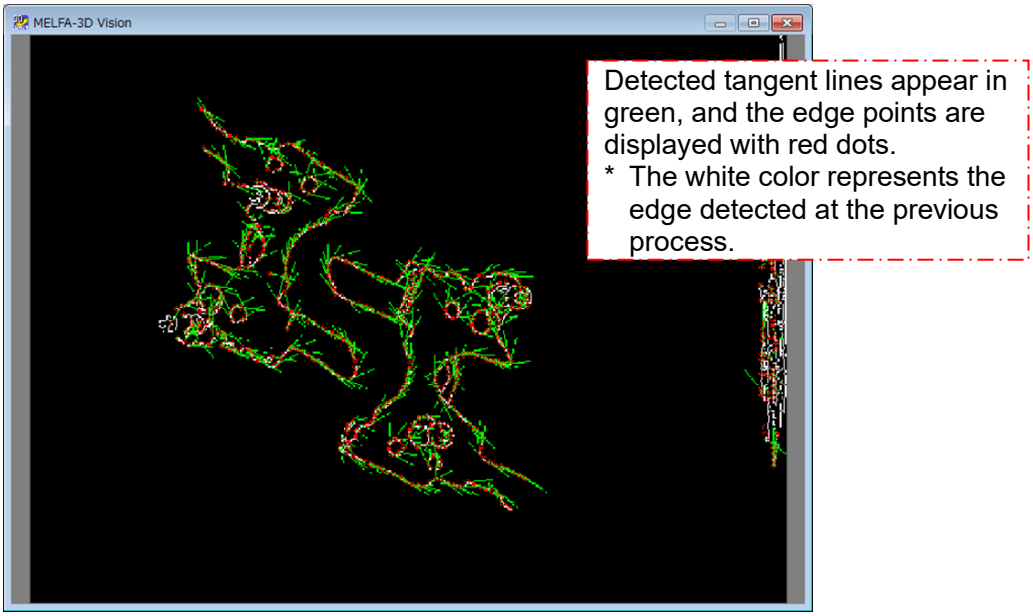


Fig. 7-146 Successful example of detected tangent lines

Table 7-35: 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. 7-147 Recognition processing

Table 7-36: 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

Parameter	Unit	Description	Range	Default setting
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: Regular 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 7-37: 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.

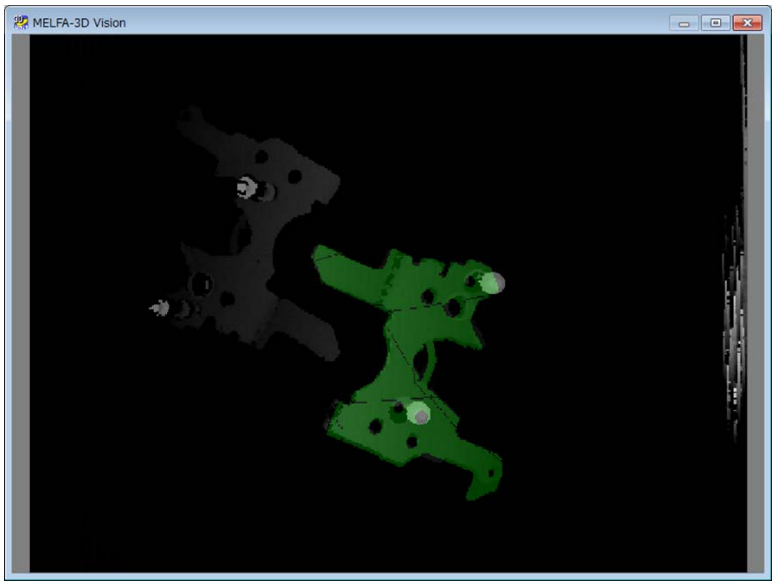


Fig. 7-148 Recognition processing successful example (2D display)

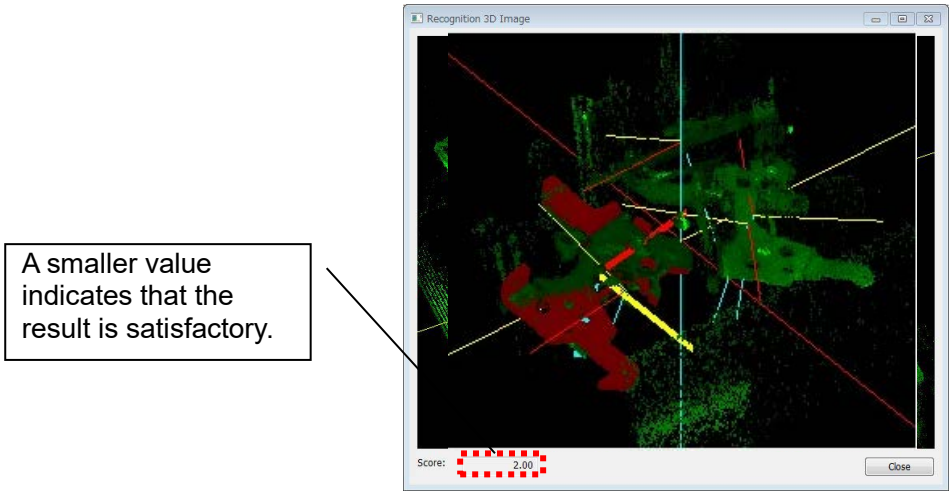


Fig. 7-149 Recognition processing successful example (3D display)

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.

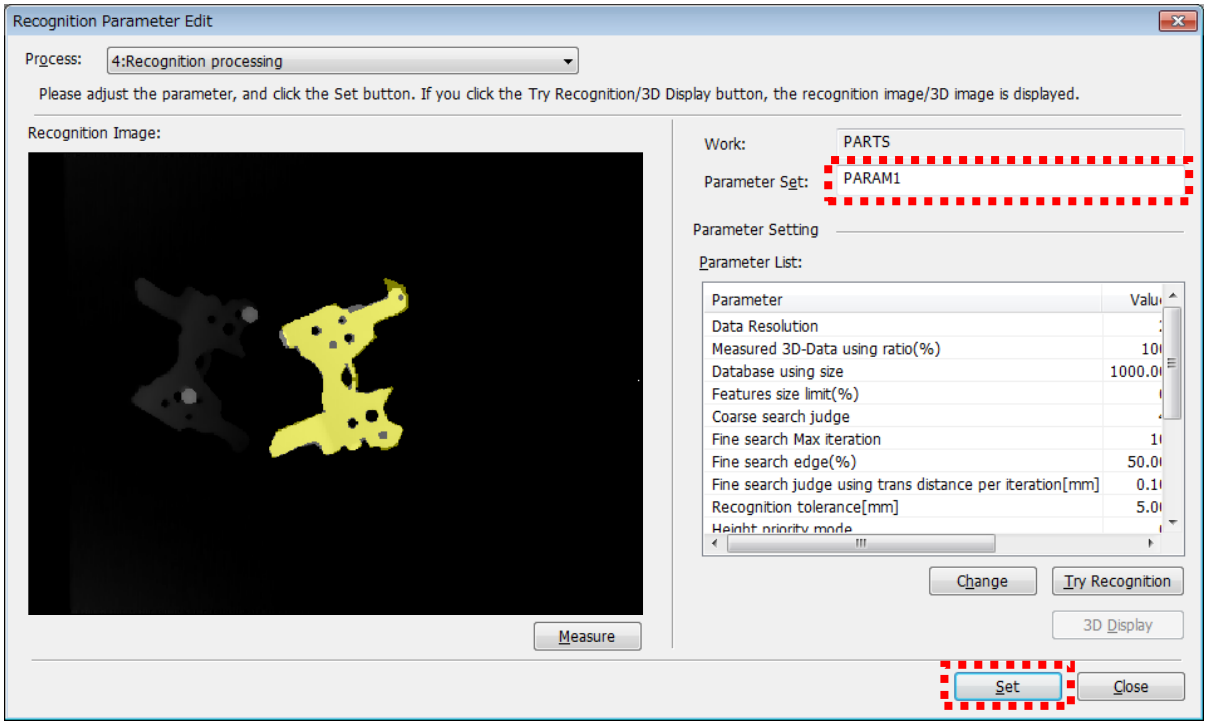


Fig. 7-150 Parameter set setting

Workpiece list registration

The following screen is used to create a workpiece list (Table 7-28). 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

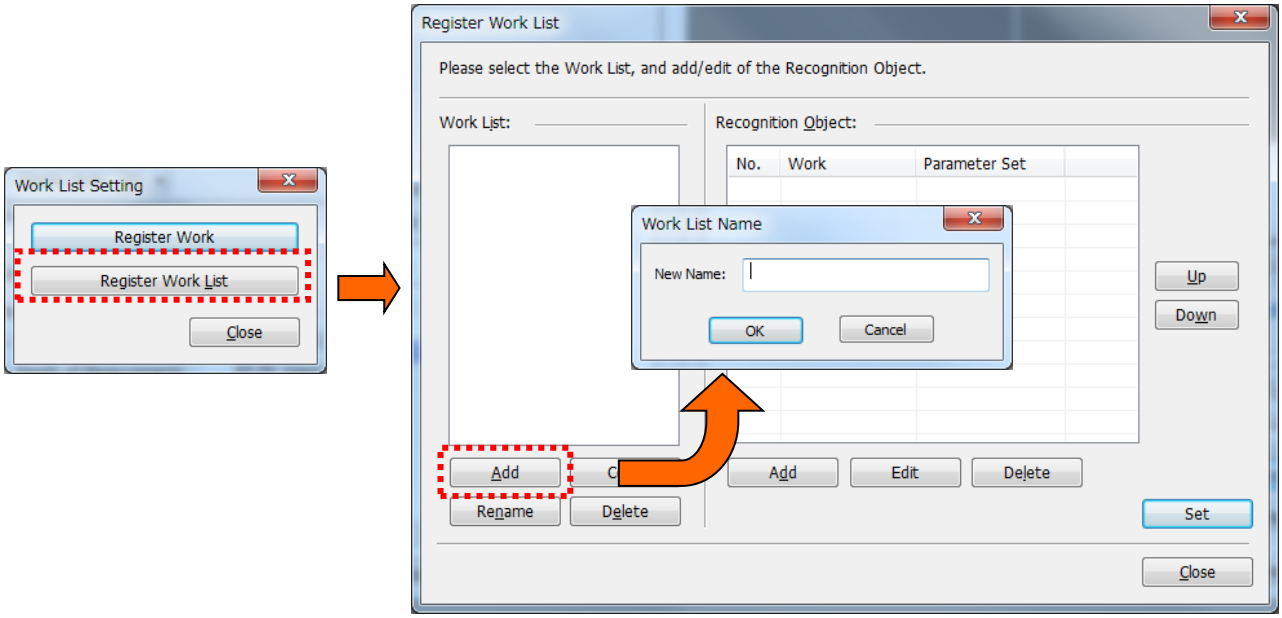


Fig. 7-151 Workpiece list registration

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.

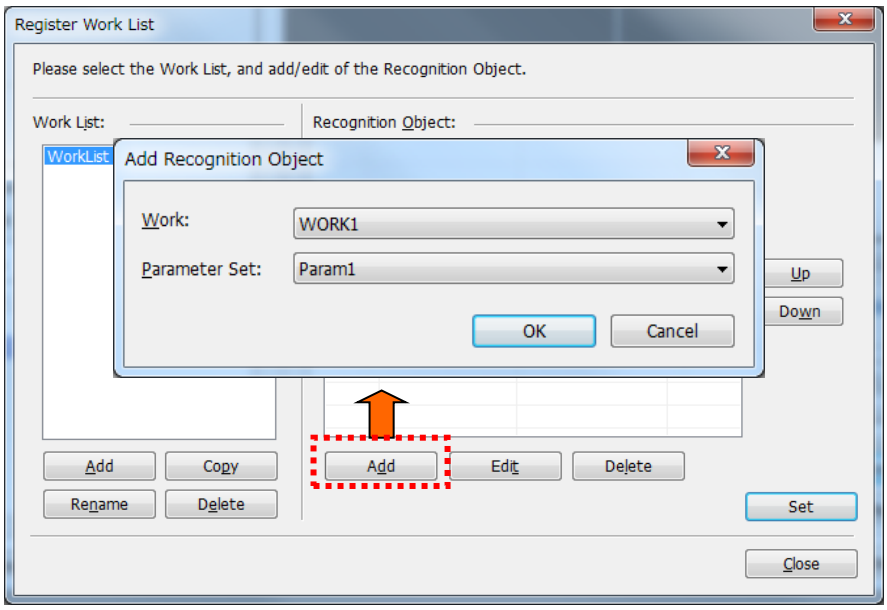


Fig. 7-152 Recognition target addition

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

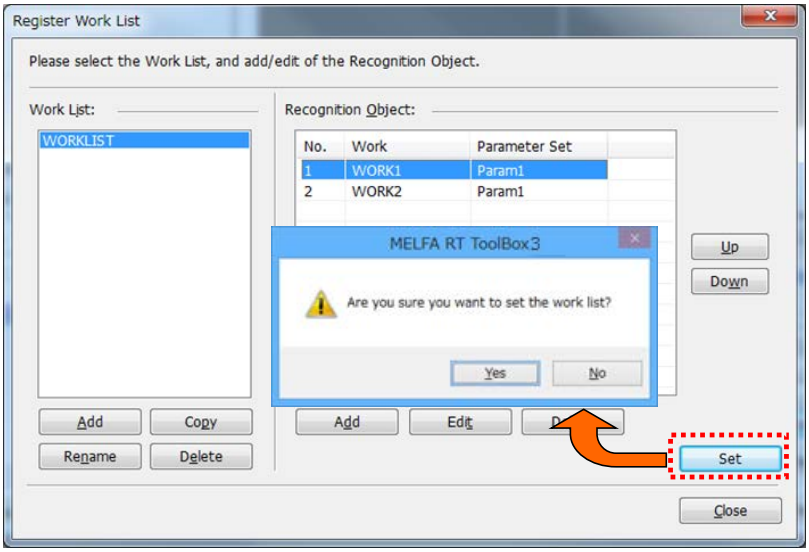


Fig. 7-153 Recognition target list

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.

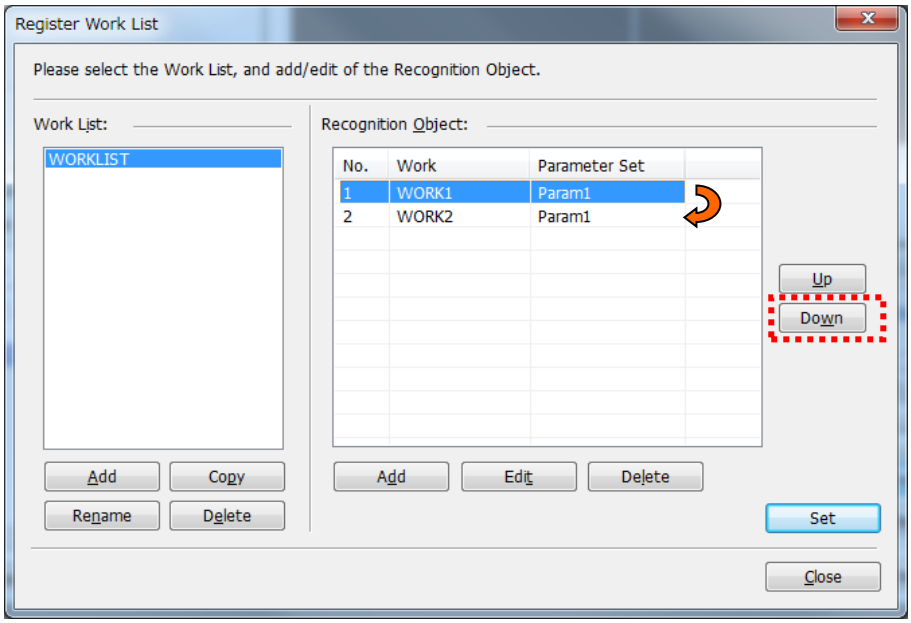


Fig. 7-154 List order change

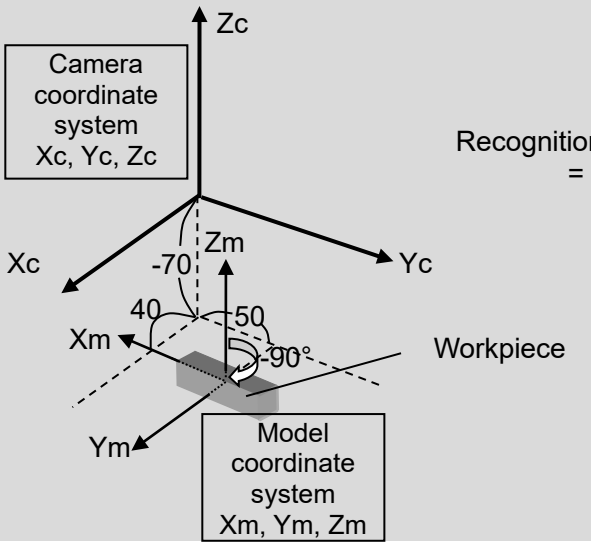
Checking the recognition results

Change the position of the workpiece in the measurement range, or increase the number of workpieces. Click the [Measure] button to perform measurement. 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. 3-14).

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◇◆◇

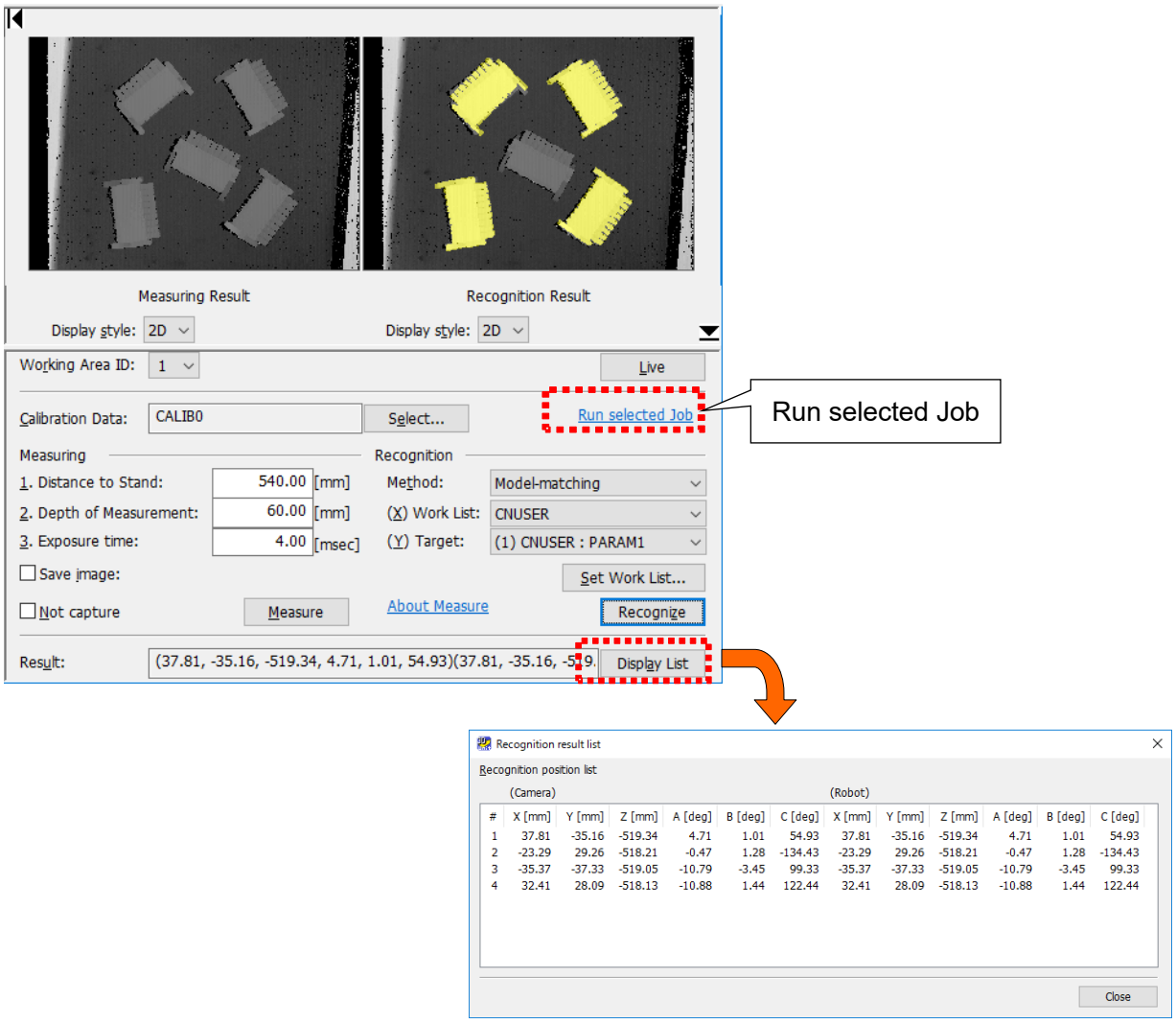
The recognition results of X, Y, and Z components represent the model coordinate system origins, and the A, B, and C components represent the model coordinate system posture (rotation around Z-axis → around Y-axis → X-axis in this order) against the camera coordinate system.



Recognition result = (X, Y, Z, A, B, C)
= (40, 50, -70, 0, 0, -90)

◇◆◇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.



* For the camera coordinates, refer to "3.4.4 Camera coordinate system".
For the robot coordinates, refer to the instruction manual "Detailed explanations of functions and operations".

Fig. 7-155 Checking the recognition results

Click the [Run selected Job] link and proceed to the job execution after the adjustment.

7.12.3.3. 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.

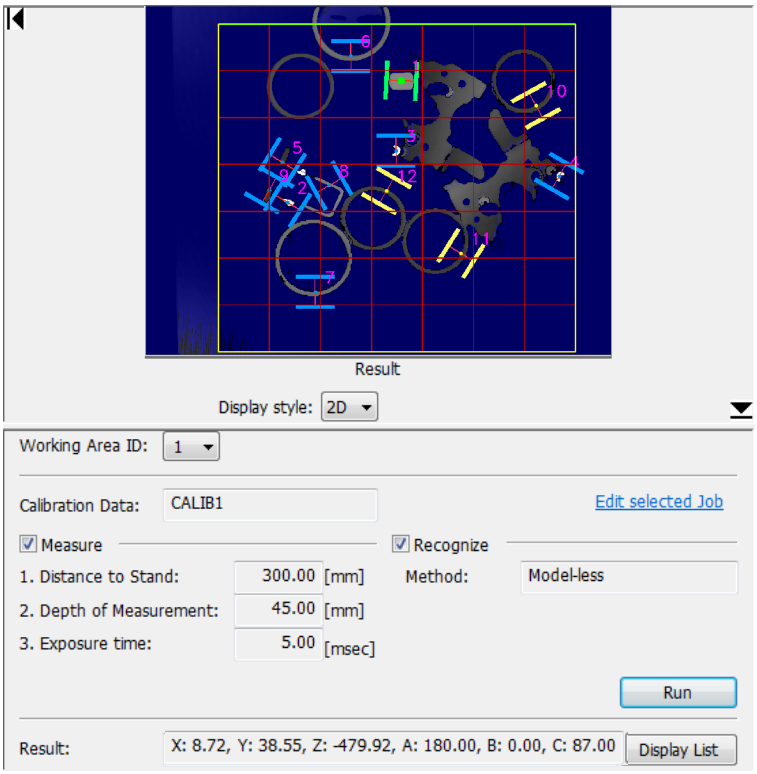
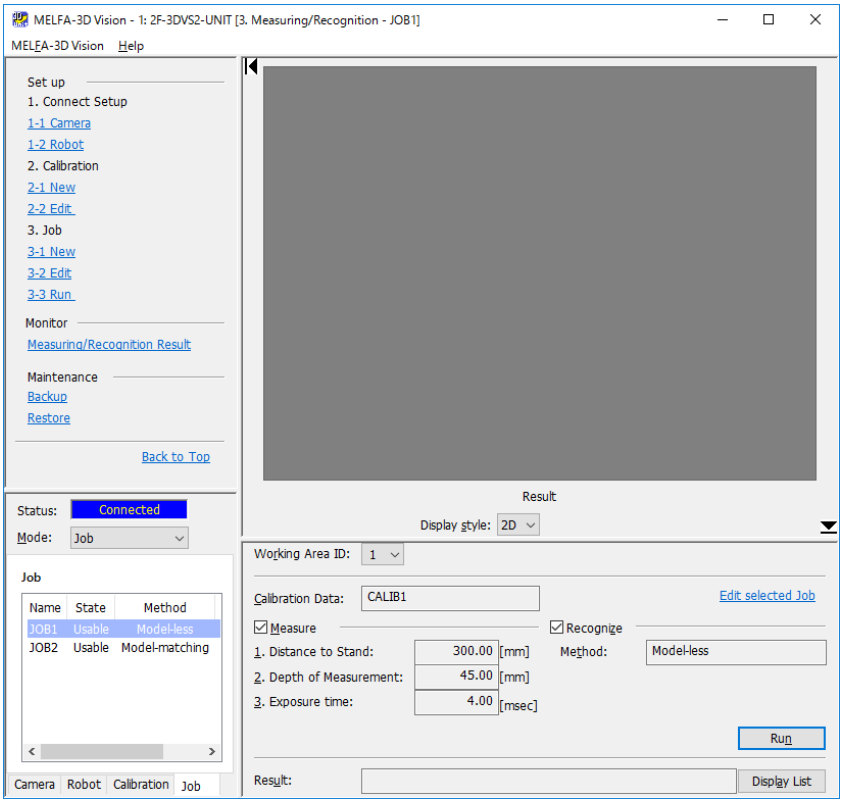
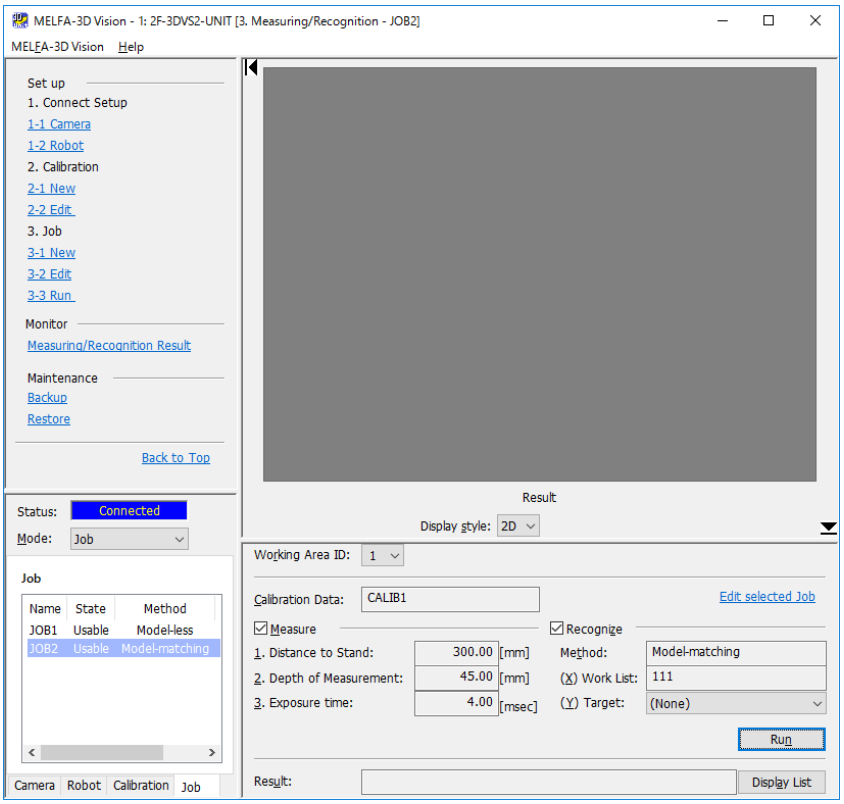


Fig. 7-156 Confirmation of recognition results

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.



Model-less recognition



Model matching recognition

Fig. 7-157 Existing job execution

7.12.4. Editing and deleting jobs

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.
For each item on the Select Job screen, refer to "Table 7-4 Information displayed on the properties monitor (job)".

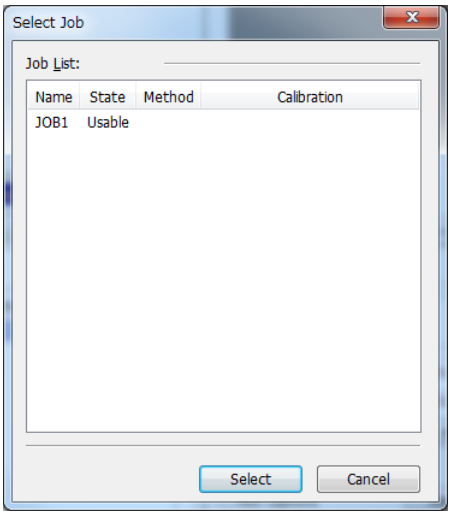


Fig. 7-158 Job selection

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.

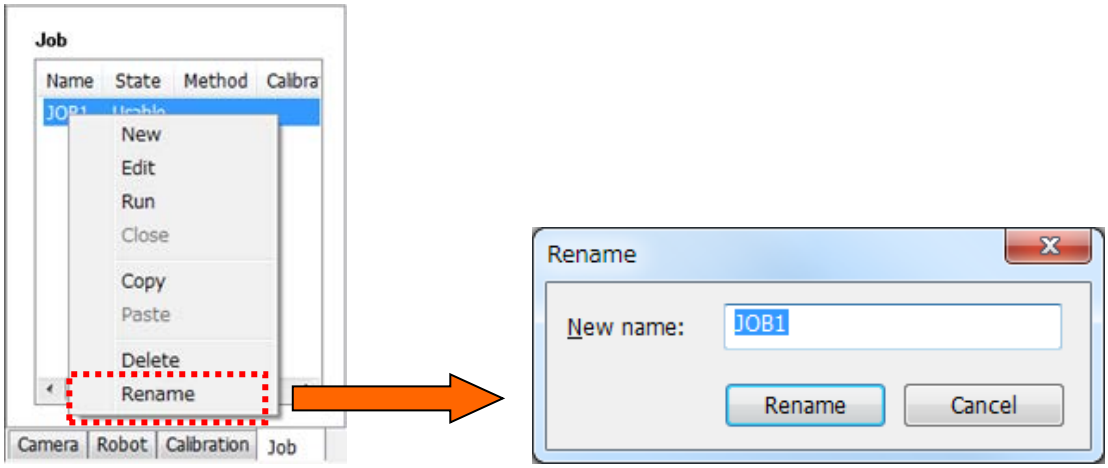


Fig. 7-159 Changing the job name

Deleting jobs

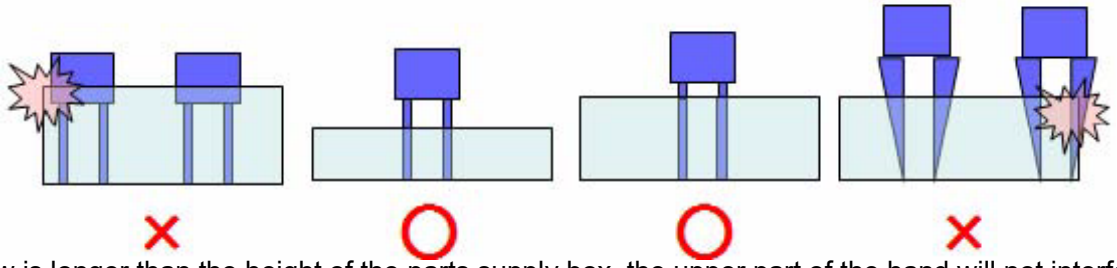
To delete a job, click [Delete] in the context menu. However, jobs that are being edited cannot be deleted.
To close the Edit screen, click [MELFA-3D Vision] - [Close job] on the menu bar.

7.13. Picking

7.13.1. Hand claw shape

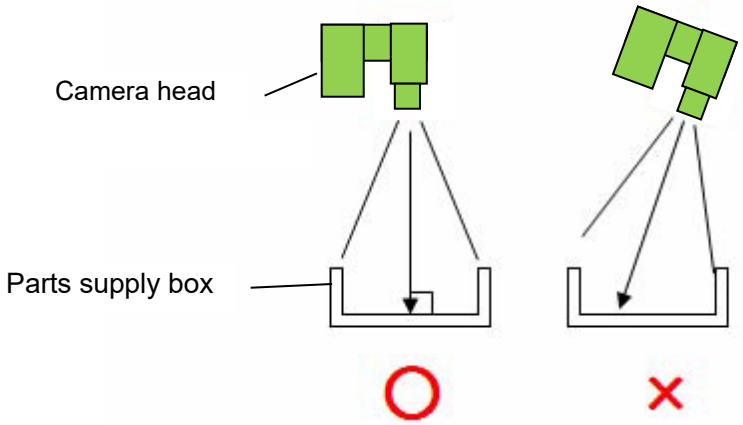
When using model-less recognition, it is necessary to pay attention to the following points when designing the hand claw in order to avoid interference with the parts supply box as shown in the above drawing.

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

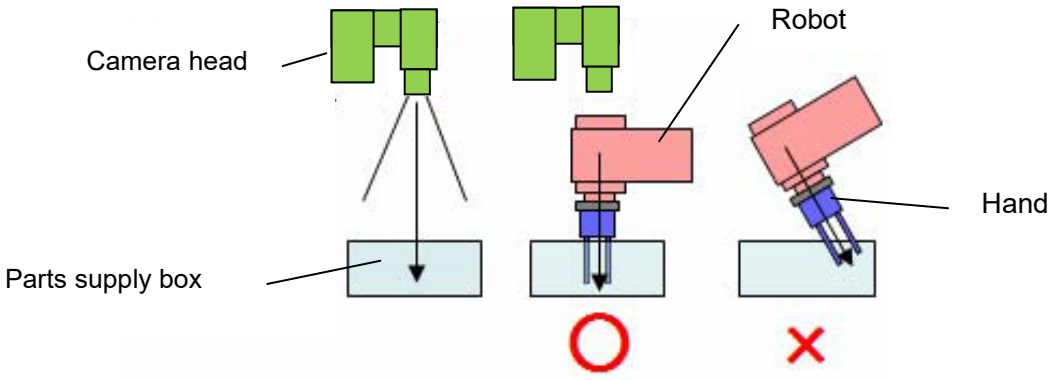


If the claw is longer than the height of the parts supply box, the upper part of the hand will not interfere with the box, however, if the claw thickness is not uniform as shown in the drawing in the upper right, the upper portion of the claw may interfere with the box when picking parts from the edge 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.

7.13.2. 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.

7.13.3. 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".

7.13.3.1. 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.

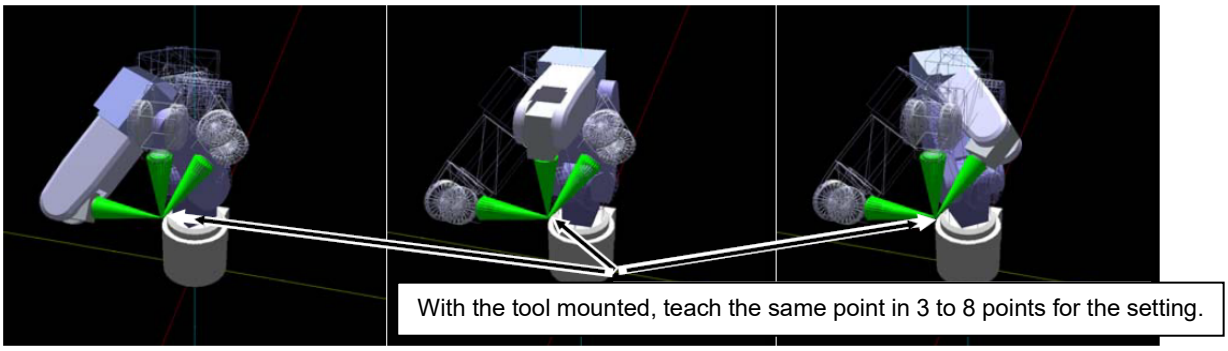


Fig. 7-160 Tool automatic calculation overview

The tool automatic calculation function is used with RT ToolBox3 connected to the robot controller. Select [Online] - [Maintenance] for the applicable project from the project tree, and then double-click [Tool automatic calculation].

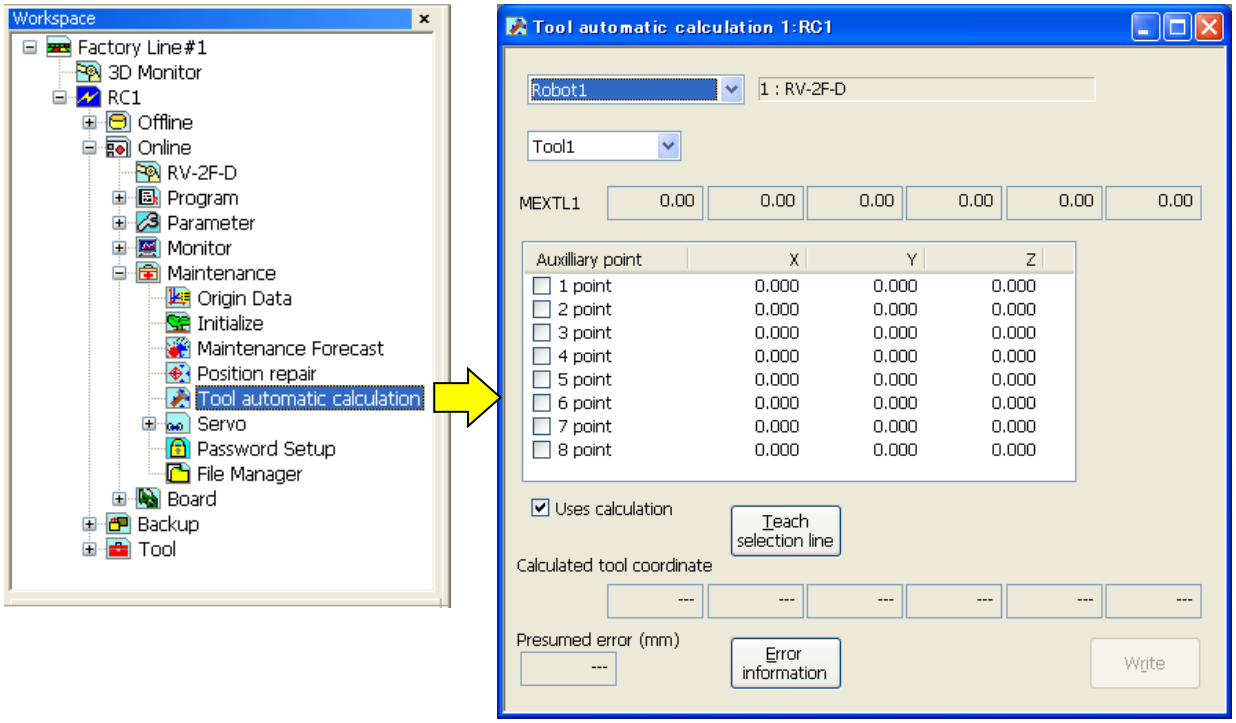


Fig. 7-161 Starting tool automatic calculation

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.

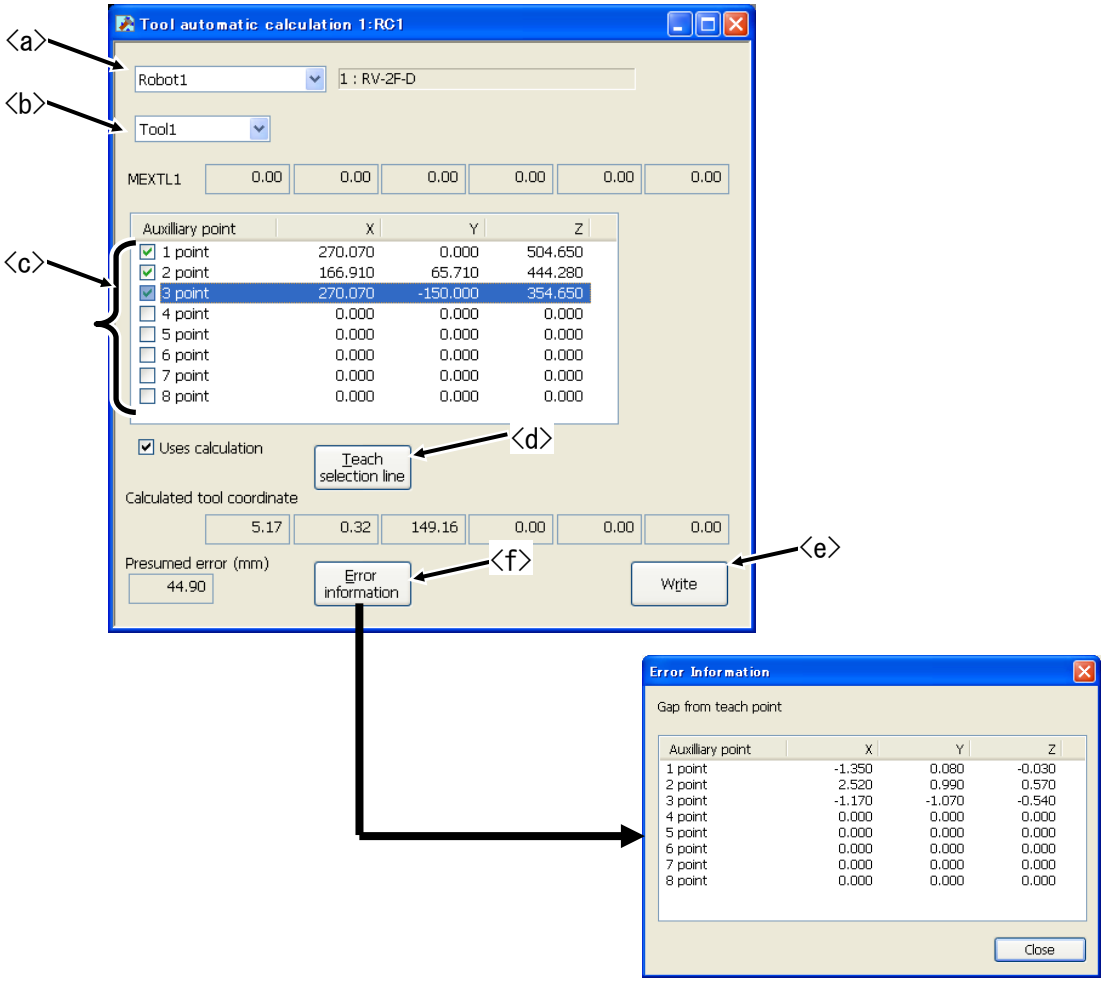
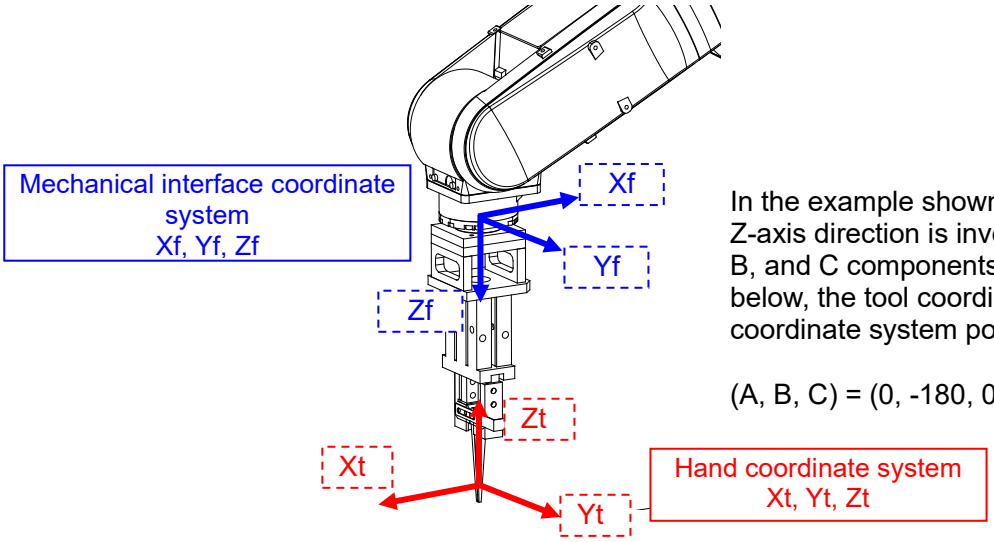


Fig. 7-162 Performing tool automatic calculation

◇◆◇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.

7.13.3.2. 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.

(A, B, C) = (0, -180, 0)

Fig. 7-163 Tool A, B, and C component setting example

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

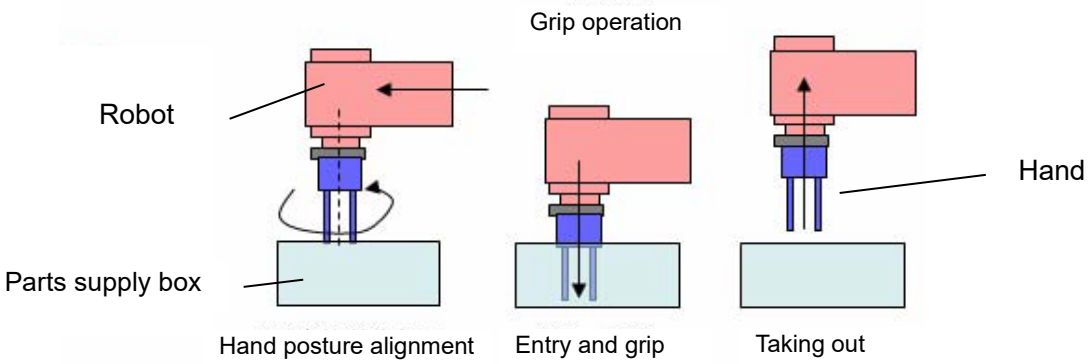
•Based on the value set for the recognition parameter posture output mode, the Z-axis direction of the hand coordinates system matches the Z-axis direction of the mechanical interface coordinates system. (Refer to Table 7-24 Recognition parameters)

⚠ 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.

7.13.4. Creating robot programs

7.13.4.1. 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

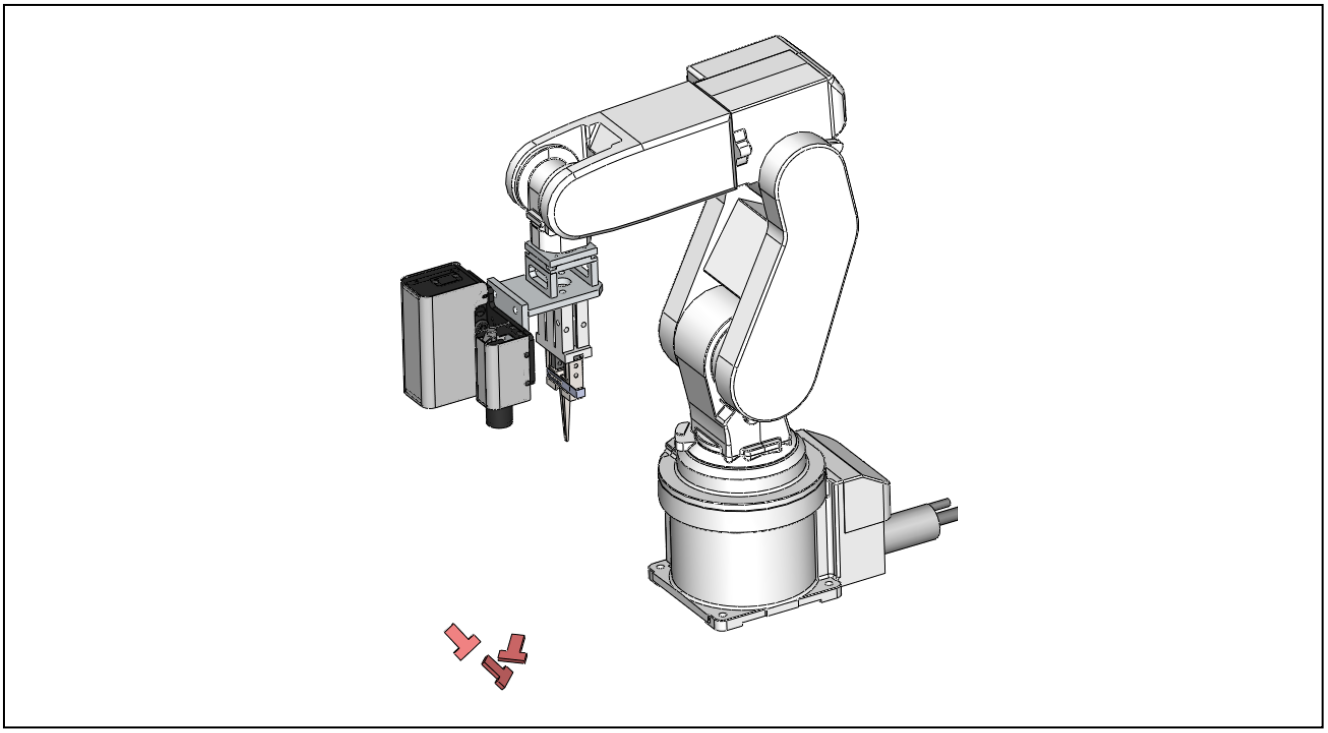
■ Operation details

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.

⚠ CAUTION

Since checking of interference with surrounding objects when gripping a workpiece is not performed, load workpieces in bulk on a flat surface without using a parts supply box when the posture output mode 2, 4, 5, or 6 is selected.



■ Program example <Sample Program JMLH.prg>

* This program is for the RV-F/RV-FR series.
When using the program in the RH-F/RH-FR series, refer to Note 3.

```
'[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)>+0 And Deg(PRcg.A)<+135 Then PAp.A = +135DEG  'Correction to prevent peripheral
                                                              interference Note 3
If Deg(PRcg.A)<-0 And Deg(PRcg.A)>-135 Then PAp.A = -135DEG  '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.
Hlt
End
```

Note 1: The camera installation type set in the calibration data must be "Hand".
Note 2: Indicates the correction value to prevent the camera head from colliding with the robot arm. The correction value differs depending on the relationship between the camera and hand postures or measurement posture.
Note 3: When using the RH-F/RH-FR series robot, change these four lines into comments.
Note 4: Set the thrust amount to roughly three fourths of the workpiece height.

Bulk picking using fixed camera

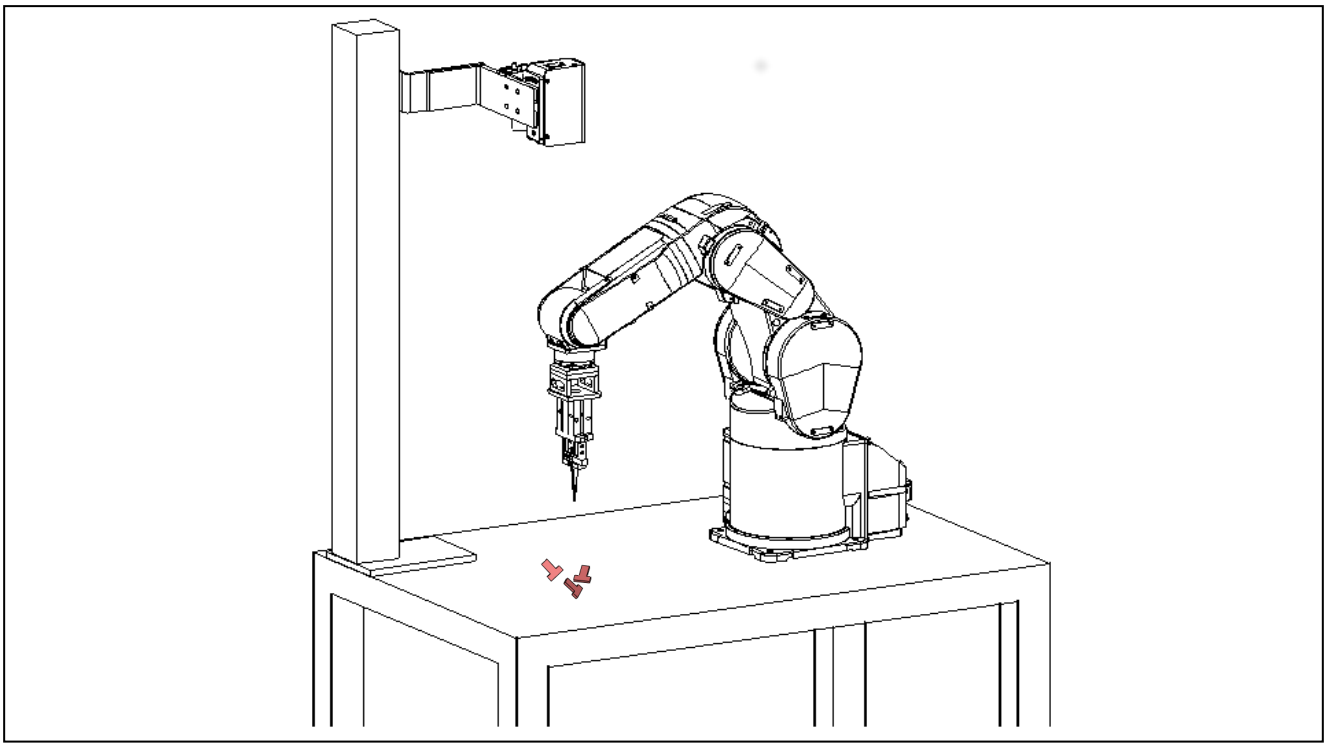
■ Operation details

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.

⚠ CAUTION

Since checking of interference with surrounding objects when gripping a workpiece is not performed, load workpieces in bulk on a flat surface without using a parts supply box when the posture output mode 2, 4, 5, or 6 is selected.



■ Program example <Sample Program JMLF.prg>

*This program is for the RV-F/RV-FR series.
When using the program in the RH-F/RH-FR series, refer to Note 2.

```
'[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)>+0 And Deg(PRcg.A)<+135 Then PAp.A = +135DEG     'Correction to prevent peripheral
                                                                   interference Note 2
  If Deg(PRcg.A)<-0 And Deg(PRcg.A)>-135 Then PAp.A = -135DEG     '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.
Hlt
End
```

Note 1: The camera installation type set in the calibration data must be "Fixed".
Note 2: When using the RH-F/RH-FR series robot, change these four lines into comments.
Note 3: Set the thrust amount to roughly three fourths of the workpiece height.

7.13.4.2. Model matching recognition

Grip posture teaching

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.

***Model matching recognition is available only for RV series.**

(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.

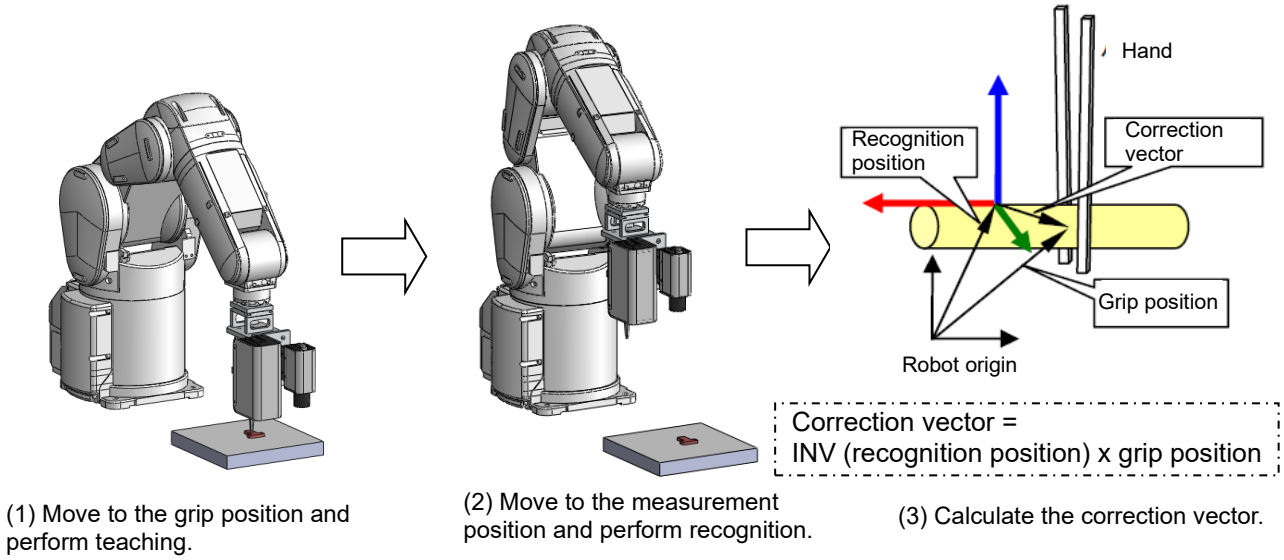


Fig. 7-164 Correction vector calculation

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.

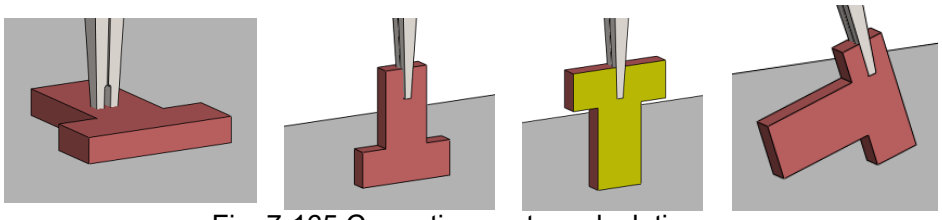


Fig. 7-165 Correction vector calculation

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 ToolBox3] 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.
Hlt
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.

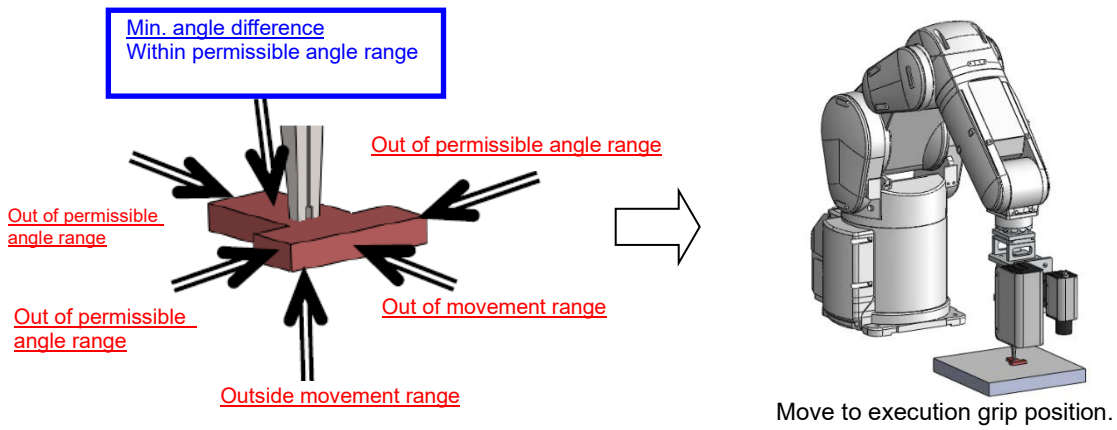


Fig. 7-166 Movement to where the robot grasps a workpiece

A sample program is shown below.

Random picking

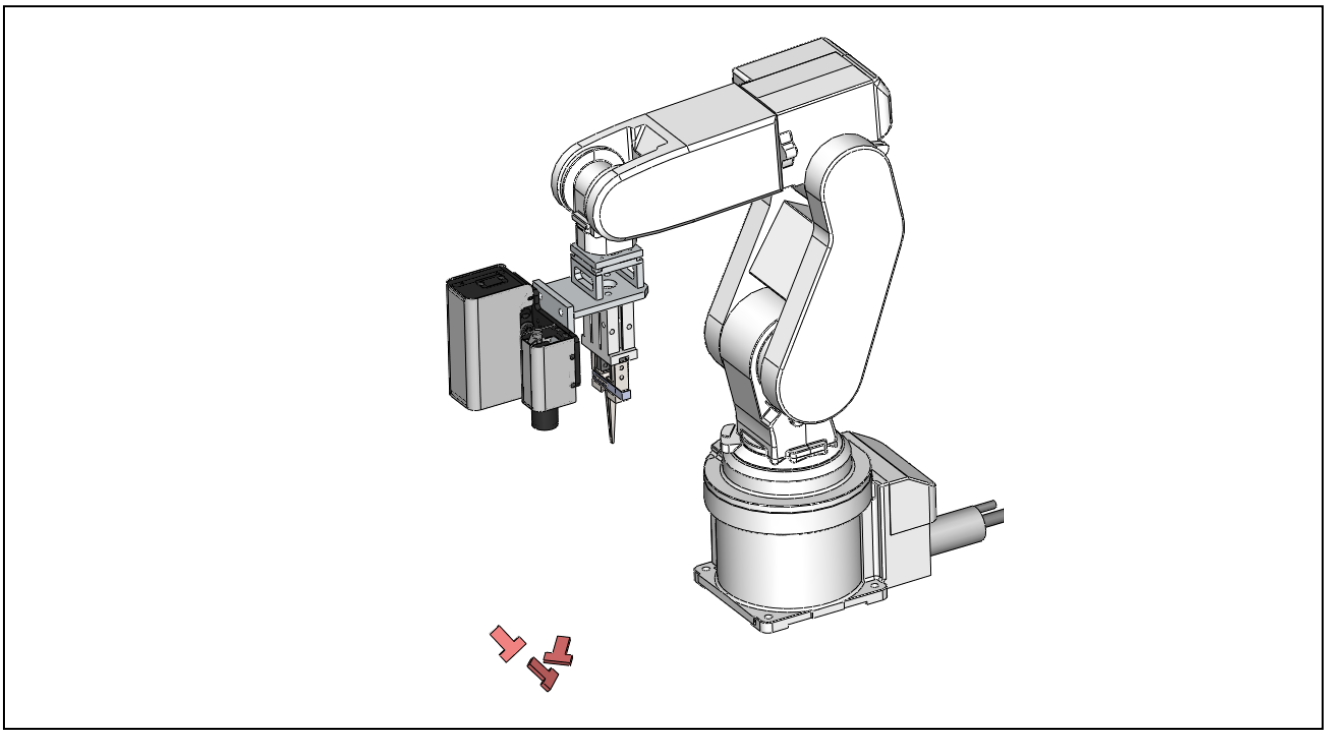
■ Operation details

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.
Hlt
End
```

Note 1: See 8.1

7.13.5. Operation check

7.13.5.1. 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.

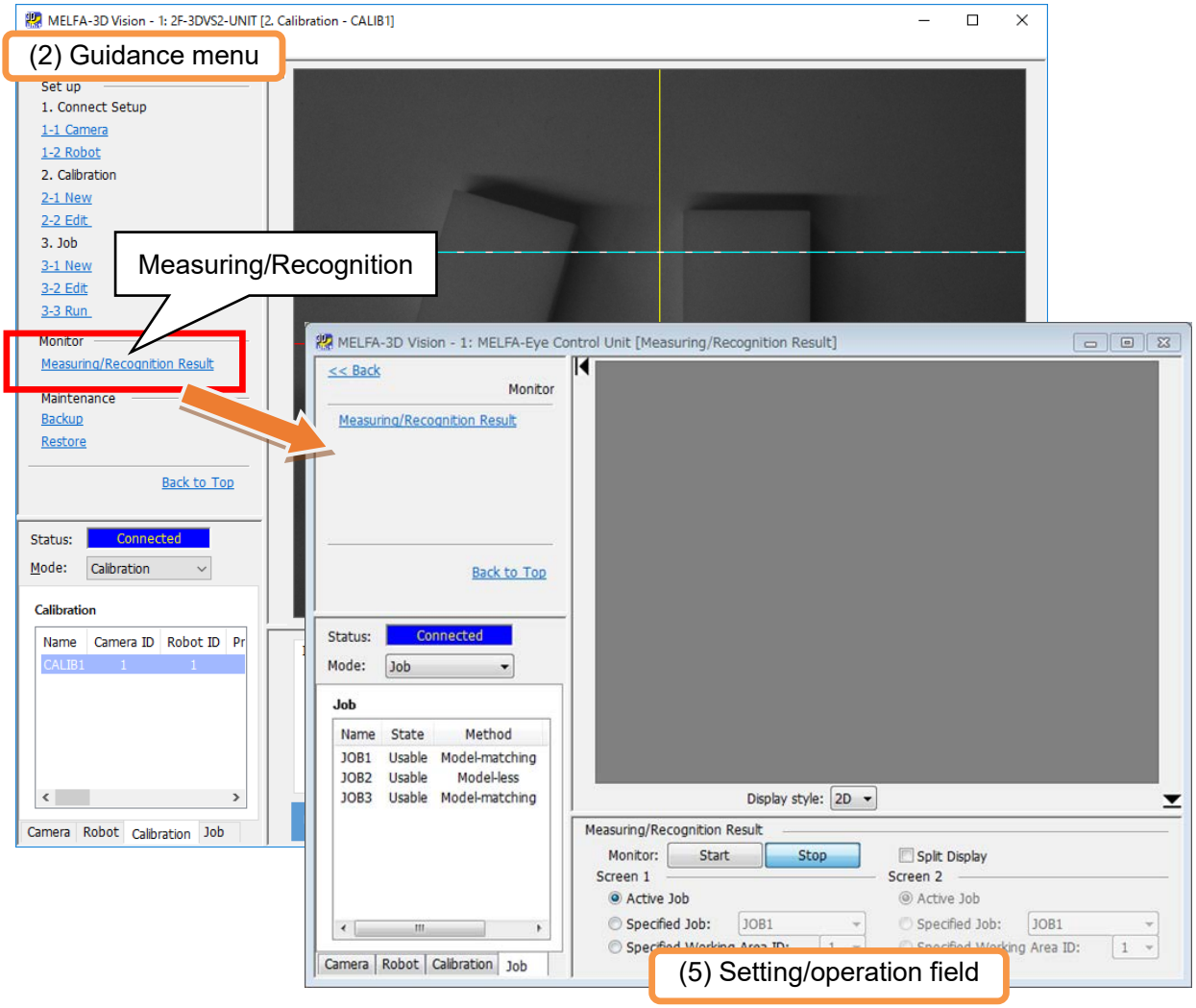


Fig. 7-167 Measurement and recognition results

The monitoring target can be selected from the following three.

Table 7-38 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.

7.14. Maintenance

7.14.1. 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.

Table. 7-39: 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.

CAUTION

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.

CAUTION

The data backed up in the conventional control unit cannot be restored to this software.

7.14.1.1. 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.

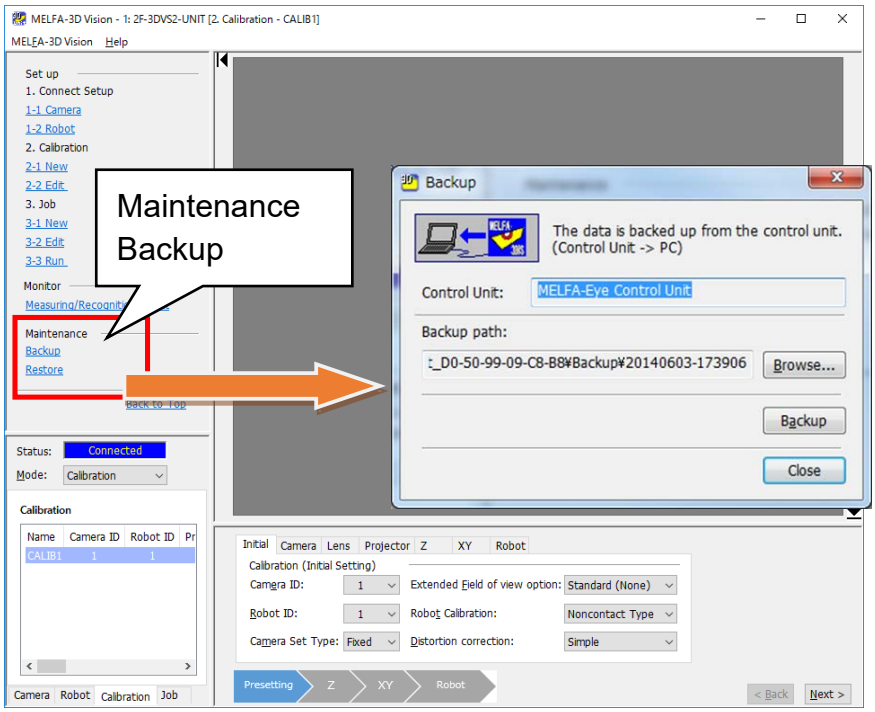


Fig. 7-168 Backup

Specifying the backup location

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.

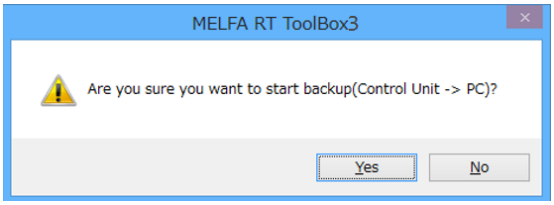


Fig. 7-169 Backup confirmation screen

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

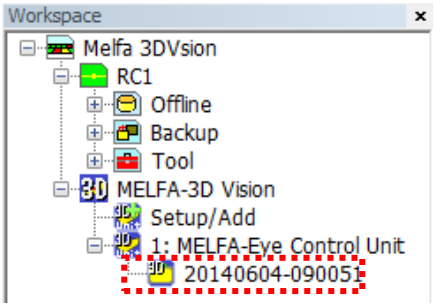


Fig. 7-170 Backed up information display

7.14.1.2. 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.

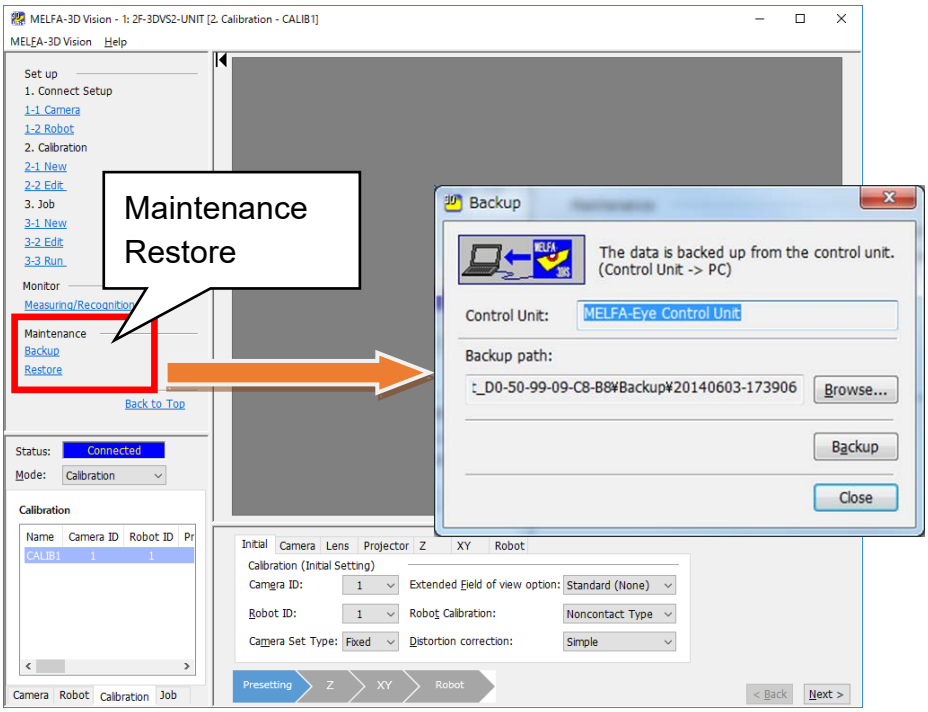


Fig. 7-171 Restoration

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.

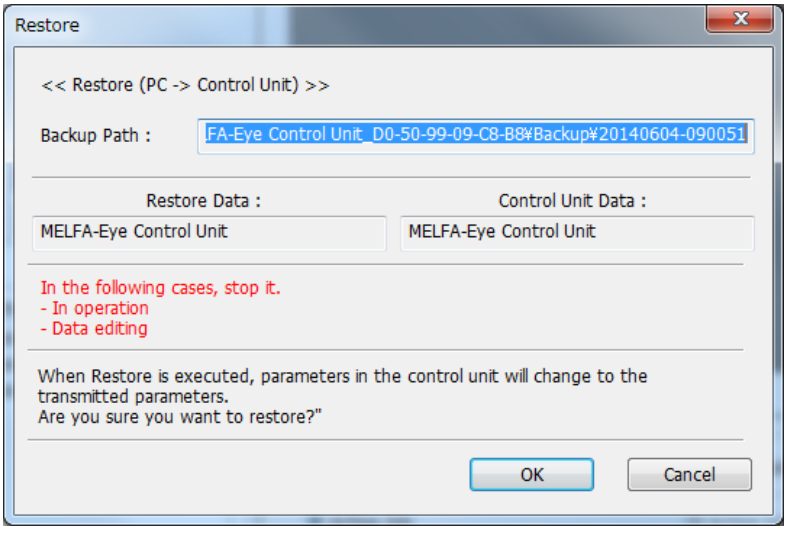


Fig. 7-172 Restoration confirmation screen

7.14.2. Uninstallation procedure

7.14.2.1. MELFA-3D Vision software uninstallation

Start "Setup.exe" in the CD-ROM.
Or, select "MELFA-3D Vision" from "Control Panel\All Control Panel Items\Program and Features", and click "Uninstall".
*The language selected at the time of installation is used.

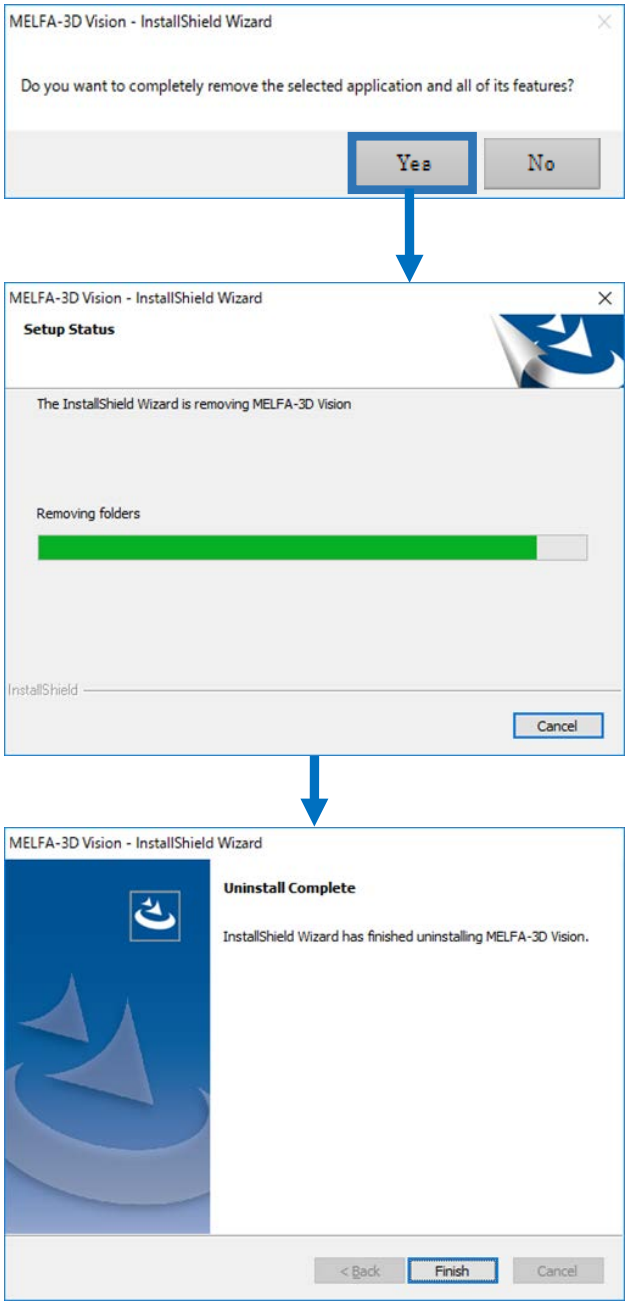


Fig. 7-173 MELFA-3D Vision software uninstallation procedure

7.14.2.2. Camera driver uninstallation

*Perform the uninstallation manually before updating the camera driver.

Select "pylon 5 Runtime 5.0.10.10613" from "Control Panel\All Control Panel Items\Program and Features", and click "Uninstall".

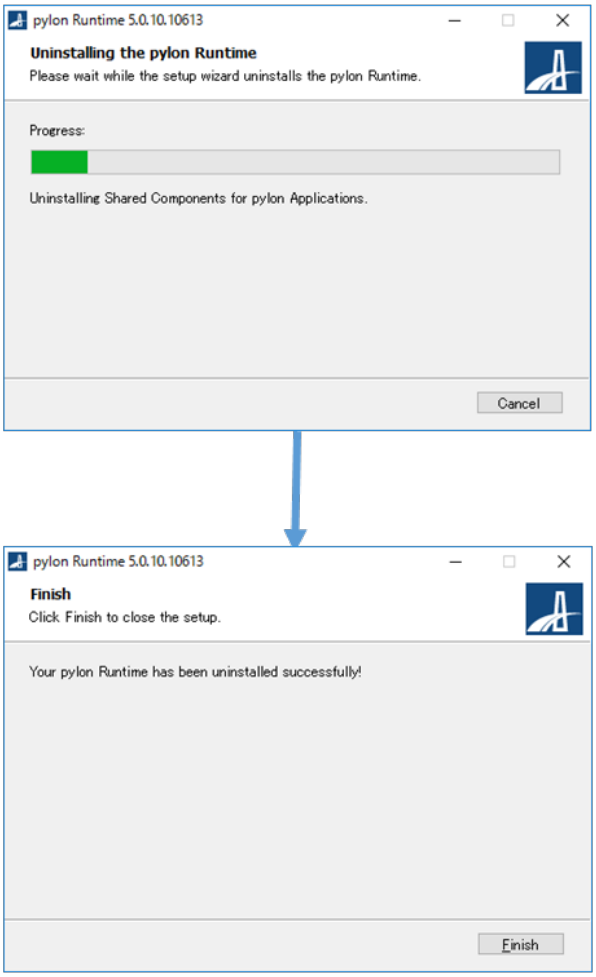


Fig. 7-174 Camera driver uninstallation procedure

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. ROBOT PROGRAM 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

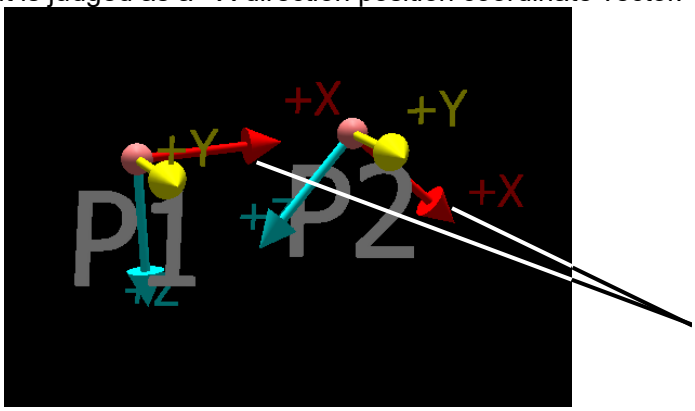
[Function]
Converts two specified position coordinates to unit vectors, and returns the result of inner product.

[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.



Used as a vector in the +X direction

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: -π/2 to +π/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. (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
M_V3Rmn (n) Note 4 n = Storage destination No.	Storage destination No. 1 to 10	Refers to the workpiece residual amount calculated based on the height information with model-less recognition of MELFA-3D Vision. For the storage destination No., specify the storage destination No. 1 to 10 specified with the V3Run command. -1: Initial value	R/W Note 2	Integer type
M_V3Rmn2 (n) Note 4 n = Storage destination No.	Storage destination No. 1 to 10	Refers to the workpiece residual amount calculated based on the recognition range information with model-less recognition of MELFA-3D Vision. For the storage destination No., specify the storage destination No. 1 to 10 specified with the V3Run command. -1: Initial value	R/W Note 2	Integer 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: For CR750/CR751 series controllers, the upper limits of the recognition number and the data / index number change depending on the software version.
· Ver.R6e/S6e or later: Up to 50
· Ver.R6e/S6e or earlier: Up to 10
Note 4: Available with the CR800 series controller Ver.A3 or later.

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
* For the error details, refer to "10.4 MELFA-3D Vision Error Code Details".

[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.
(3) To execute the job created using the MELFA-3D Vision extended function, the MELFA Smart Plus card needs to be set. When the MELFA Smart Plus card is set, the error No. 3780 (Cannot use the MELFA Smart Plus.) is stored.

[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: For CR750/CR751 series controllers, the upper limit of the recognition number changes depending on the software version.

- 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: For CR750/CR751 series controllers, the upper limit of the data number changes depending on the software version.

- 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_V3Rmn1

[Function]
Refers to the workpiece residual amount calculated based on the height information with model-less recognition of MELFA-3D Vision.

[Syntax]

<Numeric variable> = M_V3Rmn1[(<Storage destination No.>)]

[Term]
<Position variable>
Specifies a position 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
<Position 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), △ (× 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	○	○	△	△	×	×
Variable	○	○	△	△	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

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

[Example]
1 1 MRmn1 = M_V3Rmn1(1) Obtain the workpiece residual amount.

[Description]
(1) When the workpiece residual amount is not calculated, "-1" is returned. Check the parameter of the recognition job for MELFA-3D Vision and set it to calculate the workpiece residual amount. (The initial value is "-1".)

[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

M_V3Rmn2

[Function]
Refers to the workpiece residual amount calculated based on the recognition range information with model-less recognition of MELFA-3D Vision.

[Syntax]

<Numeric variable> = M_V3Rmn2[(<Storage destination No.>)]

[Term]
<Position variable>
Specifies a position 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
<Position 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), △ (× 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	○	○	△	△	×	×
Variable	○	○	△	△	×	×
Logical/arithmetic expression	×	×	×	×	×	×
Function	×	×	×	×	×	×

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

[Example]
1 1 MRmn2 = M_V3Rmn2(1) Obtain the workpiece residual amount.

[Description]
(1) When the workpiece residual amount is not calculated, "-1" is returned. Check the parameter of the recognition job for MELFA-3D Vision and set it to calculate the workpiece residual amount. (The initial value is "-1".)

[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

8.3. MELFA Smart Plus Card Related Status Variables

Fig.8-3 Robot (system) status variable list

Variable name	Array qty	Function	Attributes Note 1	Data type
M_SmartPlus(ID)	ID 1	Refers to the availability of the MELFA Smart Plus function specified with <ID>.	R	Integer type
C_SmartPlus(ID)	ID 1	Returns the name of the MELFA Smart Plus function specified with <ID>.	R	Character type

Note 1: R...Read only.

M_SmartPlus

[Function]
Refers to the availability of each MELFA Smart Plus function.

[Syntax]

< Numeric variable > = M_SmartPlus(<ID>)

[Term]

< Numeric variable >	Specifies a numeric variable to be substituted. 0: Not available 1: Available
<ID>	Specifies the function ID. 1: Calibration support function 2: Robot mechanism temperature correction function 3: Additional axis cooperative control 4: Preventive maintenance 101: MELFA-3D Vision extended function

[Example]

```
1 M1 = M_SmartPlus (101)        'Refer to the availability of the MELFA-3D Vision extended function.
```

[Description]

(1) Refers to the availability of the MELFA Smart Plus function specified with <ID>.
(2) This variable is read-only.

C_SmartPlus

[Function]
Returns the name of the MELFA Smart Plus function.

[Syntax]

<Character string variable> = C_SmartPlus (<ID>)

[Term]

<Character string variable>	Specifies a character string variable to be substituted. Calibration assistance / Robot temperature compensation / Coordinated control for additional axes / Preventive Maintenance / Extended function of MELFA-3D Vision
<ID>	Specifies the function ID. 1: Calibration support function 2: Robot mechanism temperature correction function 3: Additional axis cooperative control 4: Preventive maintenance 101: MELFA-3D Vision extended function

[Example]

```
1 CMSP$ = C_SmartPlus(101)      'Obtain the name of the MELFA-3D Vision extended function.
```

[Description]
(1) Returns the name of the MELFA Smart Plus function specified with <ID>.
(2) This variable is read-only.

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.	CR750-D/CR751-D, CR800-D/R/Q) 192.168.0.20 (CR750-Q/CR751-Q) 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 last five digits can be checked in the RT ToolBox3 error details display.

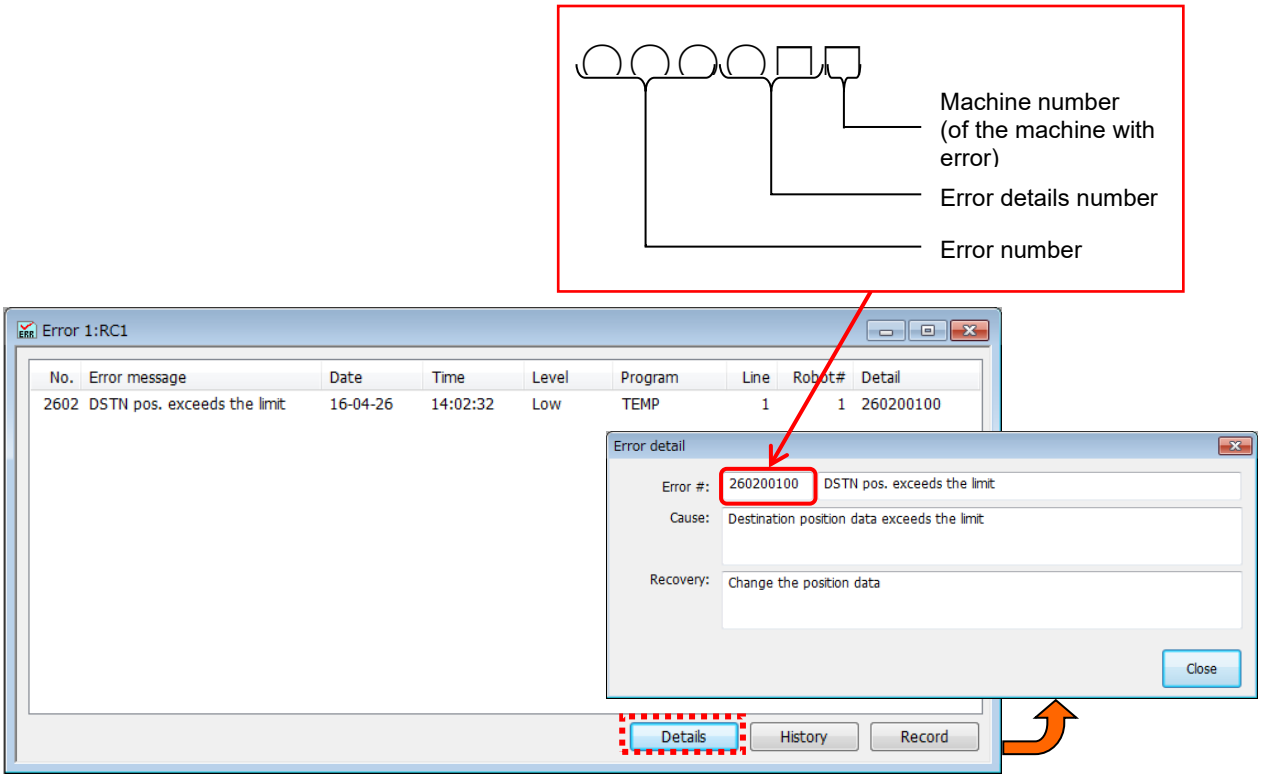


Fig. 10-1 Error details

Table 10-1: Error list

	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.		Error cause and countermeasure	
First 4 digits	Latter 5 digits		
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. MELFA Smart Plus Card Related Error Details

Table 10-3 MELFA Smart Plus card related error details

Error No.	Error cause and countermeasure	
L3780	Error message	Cannot use the MELFA Smart Plus.
	Cause	The MELFA Smart Plus card or MELFA Smart Plus card pack is inserted. If the MELFA Smart Plus card is inserted, the value of the parameter SMART+1 is not set correctly.
	Countermeasure	Insert the MELFA Smart Plus card or MELFA Smart Plus card pack. Set the value of the parameter SMART+1 correctly.
L3781	Error message	Cannot use the MELFA Smart Plus.
	Cause	The MELFA Smart Plus card or MELFA Smart Plus card pack is inserted. If the MELFA Smart Plus card is inserted, the value of the parameter SMART+1 is not set correctly.
	Countermeasure	Insert the MELFA Smart Plus card or MELFA Smart Plus card pack. Set the value of the parameter SMART+1 correctly.
L3782	Error message	Multiple MELFA Smart Plus cards are inserted.
	Cause	Multiple MELFA Smart Plus cards are inserted.
	Countermeasure	Turn OFF the controller power, and remove the unnecessary MELFA Smart Plus cards.

10.4. MELFA-3D Vision Error Code Details

The MELFA-3D Vision error codes are stored in the status variable M_V3Rslt or displayed in the error message on the MELFA-3D Vision window of RT ToolBox3.

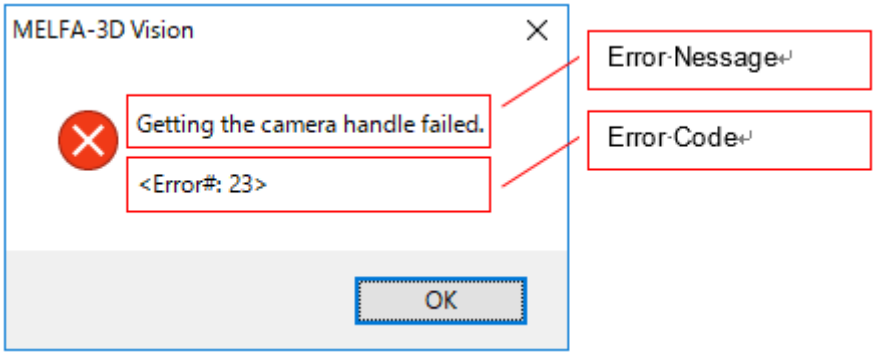


Fig. 10-4 Error message and error code

【General error】

Error code	Error cause and countermeasure	
3	Error message	The value is outside of range.
	Cause	The setting value is outside the range.
	Countermeasure	Change the setting value.
4	Error message	Defined the same name.
	Cause	The names are duplicated.
	Countermeasure	Change the names.
6	Error message	Mesure is failed.
	Cause	There is a problem with the connection among the control unit, camera, and projector.
	Countermeasure	Check the connection status between the control unit and the camera head.
7	Error message	Recognition is failed.
	Cause	Recognizing the calibration mark failed.
	Countermeasure	Adjust the position of the calibration mark so that it is within the recognition range.
9	Error message	It is used by other job.
	Cause	The measurement/recognition processing is being performed.
	Countermeasure	Wait until the measurement/recognition processing of other jobs is completed.
10	Error message	Data is full.
	Cause	The workpiece size exceeds the upper limit.
	Countermeasure	Change the workpiece model.
11	Error message	The mode does not match. Confirm the mode.
	Cause	The operation mode is not correct.
	Countermeasure	Change the operation mode.
15	Error message	Creating folder failed.
	Cause	Creating a system folder failed.
	Countermeasure	Increase the free space in the Documents folder of the user and lower. Or, check the access right of the Documents folder.
21	Error message	IP address is not set.
	Cause	The camera's IP address is not set.
	Countermeasure	Set the camera's IP address.

Error code	Error cause and countermeasure	
22	Error message	Setup of IP address failed.
	Cause	Setting the camera's IP address failed.
	Countermeasure	Check the connection status with the camera head. Turn ON the camera head power again.
23	Error message	Getting the camera handle failed.
	Cause	Getting the camera handle failed. The camera may be used in other control units.
	Countermeasure	Turn ON the camera head power again.
25	Error message	Getting the image size failed.
	Cause	The connection with the camera is not open.
	Countermeasure	Check the connection status between the power cable and the communication cable of the camera head.
26	Error message	Getting the image failed.
	Cause	There is a problem with the connection among the control unit, camera, and projector.
	Countermeasure	Check the connection status between the control unit and the camera head.
27	Error message	Invalid image.
	Cause	Measurement data is not in the workspace.
	Countermeasure	Execute the job after measurement.
28	Error message	Irradiation failed.
	Cause	There is a problem with the connection among the control unit, camera, and projector.
	Countermeasure	Check the connection status between the control unit and the camera head.
31	Error message	Connecting to the robot failed.
	Cause	The robot communication settings are not performed. Or, the communication line with the robot is not connected.
	Countermeasure	Check the robot communication settings (*1) and connection status (*2). (*1): IP address, port number (*2): LAN cable, switching hub
32	Error message	Sending to the robot failed.
	Cause	The robot communication settings are not performed. Or, the communication line with the robot is not connected.
	Countermeasure	Check the robot communication settings (*1) and connection status (*2). (*1): IP address, port number (*2): LAN cable, switching hub
35	Error message	Invalid imaging.
	Cause	The accuracy of the calibration is low. Or, recognizing the calibration mark failed.
	Countermeasure	Adjust the focus of the camera and projector again.
37	Error message	Please adjust the angle of the projector to cover the irradiation range within view.
	Cause	The pattern irradiation of the projector is not within the camera view.
	Countermeasure	Adjust the projector angle so that the pattern irradiation range is within the camera view.

【Model matching recognition related error】

Error code	Error cause and countermeasure	
41	Error message	Failed to detect edge information for pose estimation.
	Cause	The edge information necessary for recognition was not detected.
	Countermeasure	Adjust the value of the edge extraction parameter.
43	Error message	The number of sampling points for pose estimation is too little.
	Cause	The number of sampling points necessary for recognition could not be obtained.
	Countermeasure	Adjust the value of the boundary point sampling interval. Register the workpiece model again.
44	Error message	The number of extracted features for pose estimation is too numerous.
	Cause	Since the memory is insufficient, the number of the extracted features exceeds the upper limit.
	Countermeasure	Adjust the value of the boundary point sampling interval. Register the workpiece model again.
45	Error message	No pose estimation result.
	Cause	No posture candidates were found.
	Countermeasure	Adjust the recognition parameter. Increase the upper limit of the number of initial candidates.
46	Error message	Alignment error between a CAD model and 3D scan data is too large.
	Cause	The posture candidates were found, but the recognition error is too large.
	Countermeasure	Adjust the recognition parameter.
47	Error message	Registered model is invalid.
	Cause	The registered workpiece model data is damaged.
	Countermeasure	Register the workpiece again.

【System related error】

Error code	Error cause and countermeasure	
50	Error message	The Control Unit is in operation.
	Cause	The measurement/recognition processing is being performed.
	Countermeasure	Wait until the measurement/recognition processing of other jobs is completed.
1001	Error message	Failed in startup the projector. There is the prospect of the failure. Please contact the manufacturer.
	Cause	Starting the projector failed.
	Countermeasure	Turn ON the camera head power again. The MELFA-3D Vision may be damaged. Contact the manufacturer.
1003	Error message	It does not match the version of MELFA-3D Vision.
	Cause	The versions of MELFA-3D Vision and RT ToolBox3 do not match.
	Countermeasure	Check the software version, and install RT ToolBox3 or the MELFA-3D Vision software again.

【Communication related error】

Error code	Error cause and countermeasure	
2001	Error message	The communication with the camera head is failed.
	Cause	The connection with the camera head is not open. (Camera handle error)
	Countermeasure	Check the connection status with the camera head. Turn ON the camera head power again.
2002	Error message	The camera parameter setting is outside of range.
	Cause	Setting the camera parameter failed.
	Countermeasure	Check the value of the camera parameter.
2003	Error message	The imaging is failed.
	Cause	There is a problem with the communication between the camera and the projector.
	Countermeasure	The MELFA-3D Vision may be damaged. Contact the manufacturer.
2004	Error message	There is no response from the projector.
	Cause	There is a problem with the communication between the camera and the projector.
	Countermeasure	The MELFA-3D Vision may be damaged. Contact the manufacturer.

【Calibration related error】

Error code	Error cause and countermeasure	
3001	Error message	Paremeters to compensate for lens distortion are not calculated.
	Cause	The lens distortion correction has not been completed.
	Countermeasure	Perform the lens distortion correction.
3002	Error message	Select the two ore more image ID at least.
	Cause	The necessary number of checkerboards to perform the lens distortion correction is not selected.
	Countermeasure	Select two or more checkerboards, and perform the distortion correction.
3026～3050	Error message	There is no imaging data of the image ID *.(*：image ID)
	Cause	The checkerboard of the corresponding image ID is not imaged.
	Countermeasure	Check the selection status of the image ID. After imaging the checkerboard, perform the distortion correction.
3051～3175	Error message	Failed in the corner detection of the image ID *. Please adjust the position of the checkerboard. (*：Image ID)
	Cause	Detecting the corner of the checkerboard failed.
	Countermeasure	Adjust the position of the checkerboard, and image it.
3076～3100	Error message	There is no corrected image of the image ID *.(*：Image ID)
	Cause	There is no correction image of the corresponding image ID.
	Countermeasure	Change the selection status of the image ID.
3101	Error message	Robot calibration has not been implemented.
	Cause	The robot calibration has not been completed.
	Countermeasure	Perform the robot calibration.
3102	Error message	Data cannot be registered because the number of registered data has been exceeded.
	Cause	The number of registered data exceeds the upper limit.
	Countermeasure	After deleting the unnecessary registered data, register data.
3103	Error message	XY calibration has not been implemented.
	Cause	The XY calibration has not been completed.
	Countermeasure	Perform the XY calibration.
3104	Error message	Calibration data is not selected.
	Cause	The calibration data is not selected.
	Countermeasure	Select the calibration data.

【MELFA Smart Plus function related error】

Error code	Error cause and countermeasure	
3780	Error message	Cannot use the MELFA Smart Plus.
	Cause	The MELFA Smart Plus card or MELFA Smart Plus card pack is inserted. If the MELFA Smart Plus card is inserted, the value of the parameter SMART+1 is not set correctly.
	Countermeasure	Insert the MELFA Smart Plus card or MELFA Smart Plus card pack. Set the value of the parameter SMART+1 correctly.
3781	Error message	Cannot use the MELFA Smart Plus.
	Cause	The MELFA Smart Plus card or MELFA Smart Plus card pack is inserted. If the MELFA Smart Plus card is inserted, the value of the parameter SMART+1 is not set correctly.
	Countermeasure	Insert the MELFA Smart Plus card or MELFA Smart Plus card pack. Set the value of the parameter SMART+1 correctly.

【MELFA Smart Plus AI (MELFA-3D Vision extended) function related error】

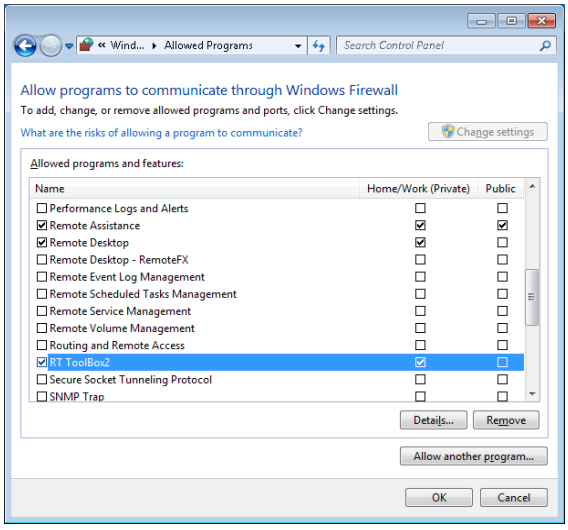
Error code	Error cause and countermeasure	
4001	Error message	Cannot start a bulk simulator.
	Cause	Starting the bulk simulator failed. Or, the bulk simulator is not started correctly.
	Countermeasure	Close the automatic adjustment screen once, and start the simulator again.
4002	Error message	Cannot close the bulk simulator
	Cause	Closing the bulk simulator failed.
	Countermeasure	If the PhysicalSim.exe process remains when Task Manager is open, close the task.
4003	Error message	Cannot run a parameter optimization.
	Cause	The parameter automatic adjustment processing failed.
	Countermeasure	Close the automatic adjustment screen once, and perform the parameter automatic adjustment processing again. Change the workpiece model and learning environment setting, and perform the parameter automatic adjustment processing again.
4006	Error message	Failed to register a work model.
	Cause	Registering the workpiece model failed.
	Countermeasure	Close the automatic adjustment screen once, and register the workpiece model again.
4007	Error message	Failed to delete the work model.
	Cause	Deleting the workpiece model failed.
	Countermeasure	Close the automatic adjustment screen once, and register the workpiece model again.
4008	Error message	Failed to calculate the center of gravity of the work model.
	Cause	Calculating the center of gravity of the workpiece model failed.
	Countermeasure	Close the automatic adjustment screen once, and calculate the center of gravity of the workpiece model again.
4009	Error message	The memory for the bulk simulator was insufficient. Close the automatic adjustment screen.
	Cause	Since the memory is insufficient, the automatic adjustment could not be performed with the specified workpiece model and learning environment.
	Countermeasure	Change to a simple shape workpiece model. Reduce the number of workpieces in the learning environment setting. Check that the computer performance meets the request specifications.

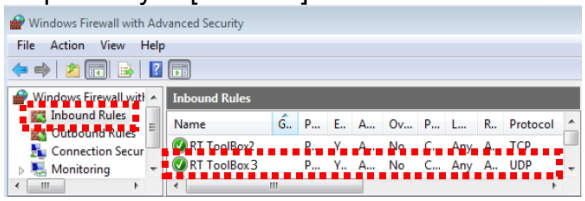
【Setting related error】

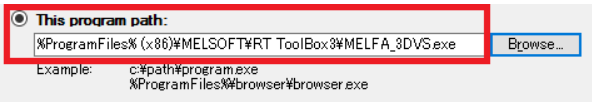
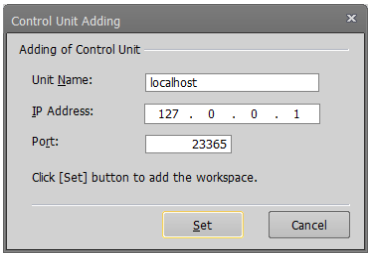
Error code	Error cause and countermeasure	
6001	Error message	It is in use on the jobs.
	Cause	Because the name is in use on the jobs, it cannot be changed.
	Countermeasure	Deselect the job, and change the name.
6002	Error message	It is in use on the work lists.
	Cause	Because the name is in use in the workpiece list, it cannot be changed.
	Countermeasure	Deselect the name in the workpiece list, and change the name.
6003	Error message	The hand is not selected.
	Cause	The hand is not selected.
	Countermeasure	Select the hand.

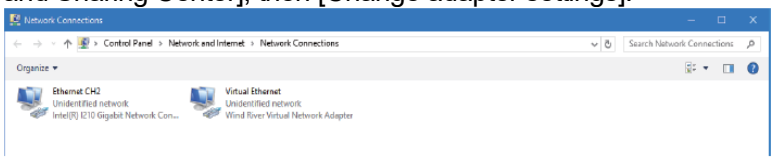
10.5. Q&A

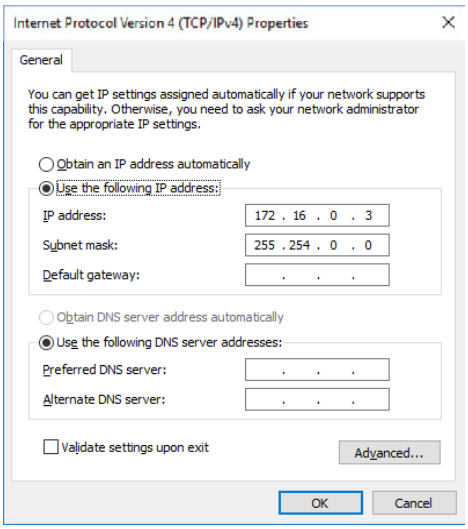
<table>
<tr><th>No.</th><th>Symptom</th><th>Cause</th><th>Measure</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">The edge computer power is ON, but the Setting and Add Control Unit window does not appear.</td><td>The application is not started.</td><td>Check that the application is started.</td></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 ToolBox3\MELFA_3DVS.exe" (if using the default installation destination). Furthermore, ensure that the RT ToolBox3 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 the installation destination to add it.
Installation destination for the RT ToolBox3 (default)
C:\Program Files\MELSOFT\RT ToolBox3\
MELFA_3DVS.exe
Select the "Domain", "Home/Work (Private)", or "Public" check box based on the usage environment, and then click the [OK] button.
 

Select [Control Panel] - [System and Security] - [Windows Firewall] - [Advanced].
On the following screen, select [Inbound Rules], then confirm that there is "RT ToolBox3", and "TCP" and "UDP" are selected respectively in [Protocol].
 
</td></tr>
</table>

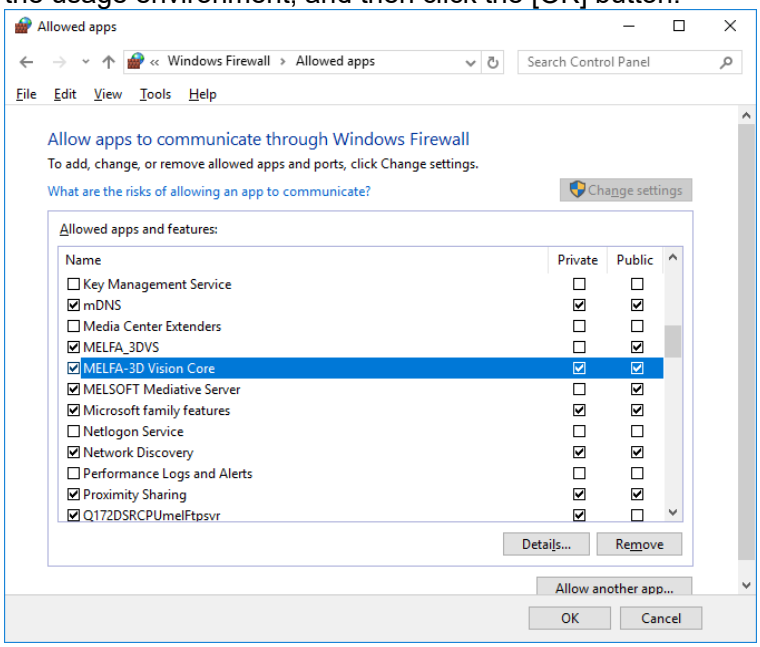
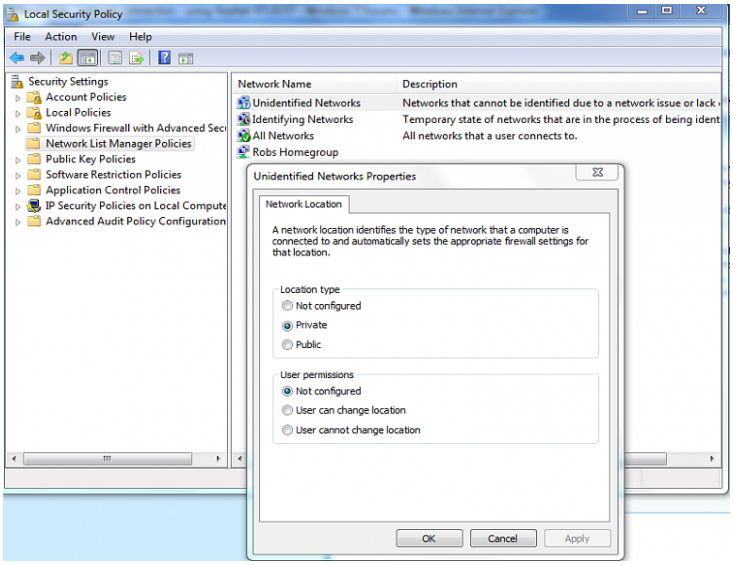
No.	Symptom	Cause	Measure
			* When the port input for UDP is not admitted: Select [New rule] from the above mentioned screen and start the new inbound rule wizard. Configure the settings as follows in each step of the wizard. <Step: Rule types> Select [Custom] and then click [Next]. <Step: Program> Select [This program path], then configure the execution file for "RT ToolBox3". [RT Toolbox3 32bit OS] %ProgramFiles%\MELSOFT \RT ToolBox3\MELFA_3DVS.exe [RT Toolbox3 64bit OS] %ProgramFiles%(x64)\MELSOFT \RT ToolBox3\MELFA_3DVS.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 ToolBox3" into [Name], then click the [Complete] button.
		Communication has been blocked by the anti-virus software.	Refer to the manual for the relevant product and specify communication permission settings for the installation destination in the firewall settings. Installation destination for the RT ToolBox3 (default) C:\Program Files\MELSOFT\RT ToolBox3\ MELFA_3DVS.exe
		When installing to the same computer as RT ToolBox3: The computer is not connected to the switching hub.	Add the control unit manually. 1. Click the [Manual addition] button on the Setting and Add Control Unit window. 2. Set the local loopback address (127.0.0.1) for IP Address in the Control Unit Adding window, and click the [Set] button. 

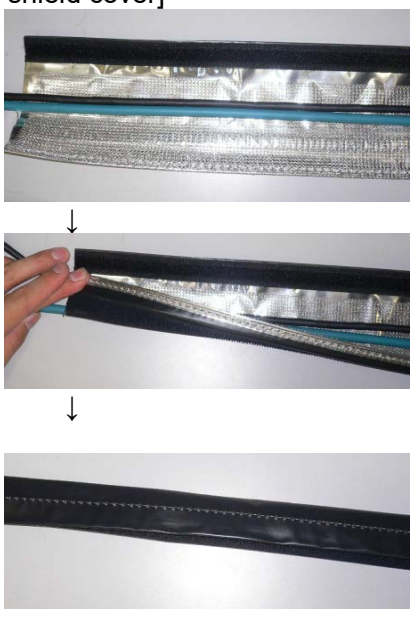
<table>
<tr><th>No.</th><th>Symptom</th><th>Cause</th><th>Measure</th></tr>
<tr><td>2</td><td>The edge computer power is ON, but the MELFA-3D Vision setting window does not appear even if double-clicking the control unit added to the workspace.</td><td>Same as No.1</td><td>Same as No.1</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Setting the camera communication failed.</td><td>The settings of the MELIPC virtual Ethernet need to be temporarily changed.</td><td>Set the MELIPC Virtual Ethernet according to Ethernet CH2.
Click [Windows Start] - [Settings] - [Network & Internet] - [Network and Sharing Center], then [Change adapter settings].
 

Right-click the virtual Ethernet and select [Properties].
Select [Internet Protocol Version 4 (TCP/IPv4)] and click the [Properties] button.
 

(Before change)
Change the IP address, subnet mask, and default gateway according to Ethernet CH2, and click the [OK] button.
Restart MELIPC, and perform the camera communication settings.
After completing the communication settings, restore the virtual Ethernet settings.
* The MELIPC virtual Ethernet is a virtual network which connects the Windows parts and VxWorks parts. Unless the settings are restored, the communication between the Windows parts and VxWorks parts will be unavailable.</td></tr>
<tr><td>Live images are displayed or pattern irradiation is being performed</td><td>If the calibration screen is displayed, close the calibration screen, and then set the communication settings of the camera.</td></tr>
</table>

No.	Symptom	Cause	Measure
4	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 "□□□-□□□-□□□-ΔΔΔ" 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.

No.	Symptom	Cause	Measure
		The MELFA-3D Vision application has been blocked by the firewall.	[Windows 10] Select [Windows Start] - [Settings] - [Network & Internet] - [Windows Firewall], or [Control Panel] - [Windows Firewall], Allow a program or feature through Windows Firewall]. Click the [Change settings] button, select MELFA-3D Vision, and select the "Domain"/"Private"/"Public" check box based on the usage environment, and then click the [OK] button.  When the problem cannot be resolved by the above measures: (Ex. When connection is performed via the local network) 1. Input the [Win] + R key, enter "secpol.msc", and click the [OK] button to open the Local Security Policy window. 2. Select [Network List Manager Policies], and double-click [Unidentified Networks] displayed in the right pane. 3. Change [Location type] to [Private], and click the [OK] button. 

5	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.
6	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 edge computer.	Ensure that the port No. at the edge computer "Robot communication settings" screen (see Fig. 7-35) is set for any of the port Nos. at the robot controller "Ethernet settings" screen (see Fig. 7-37).
7	An error occurred after executing V3Run. What the error number indicates is not clear.		Refer to "M_V3Rslt" in "8.2 MELFA-3D Vision Related Status Variables".
8	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. For example, attach the shield cover around 2 cables between the edge computer and the camera head. (Refer to 6.2 Wiring of equipment) [How to set the shield cover]  When the situation does not refine, please contact us.

9	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.
		The camera or projector may be invalid. Reset the vision sensor.	Restart the camera head or the MELFA-3D Vision application.
10	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 "SYNCIO" of the robot controller to 1 or 2).

11. APPENDIX

11.1. 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.

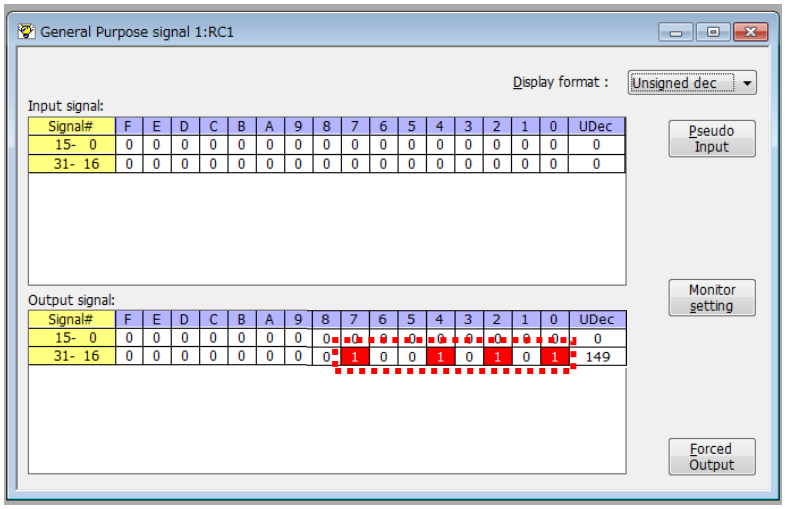


Fig. 11-1 Example of using the Ready signal

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.

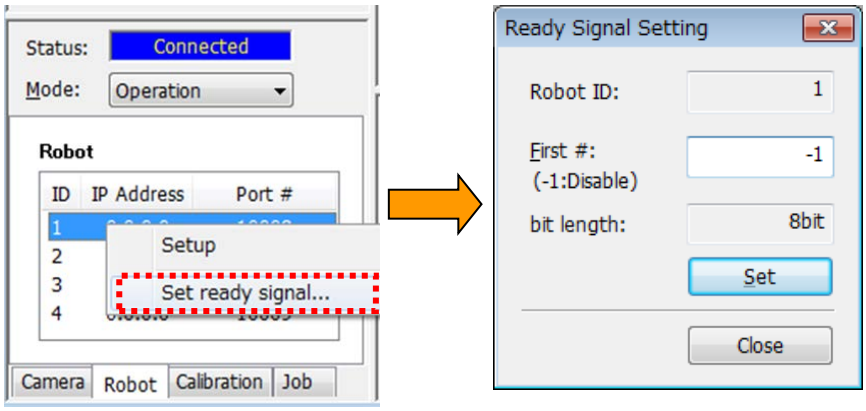


Fig. 11-2 Ready signal settings screen

◇◆◇When error4320 occurs◇◆◇
When error 4320 occurs with a robot controller after the Ready signal setting, refer to No.10 of 10.5 Q&A.

11.2. Camera Focus Adjustment Sheet

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

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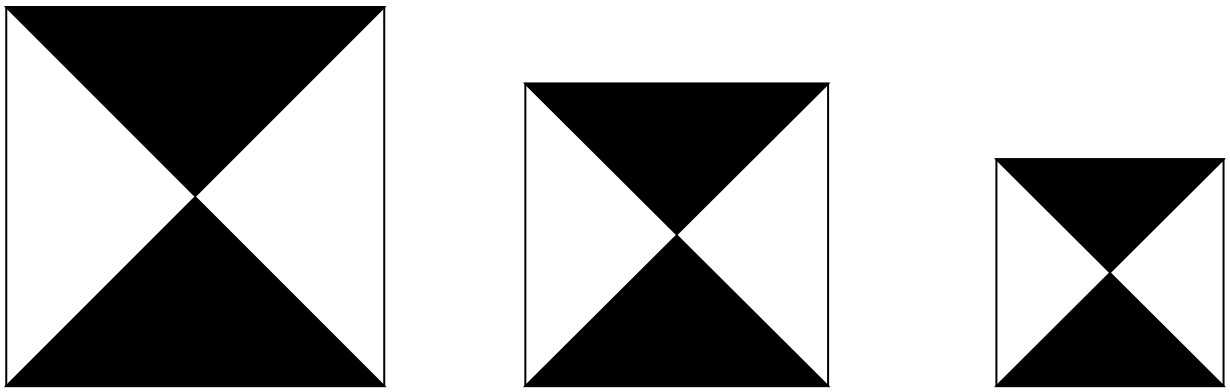
11.3. Robot Calibration Program "JRCA.prg"

```
'[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 safe 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
```

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

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

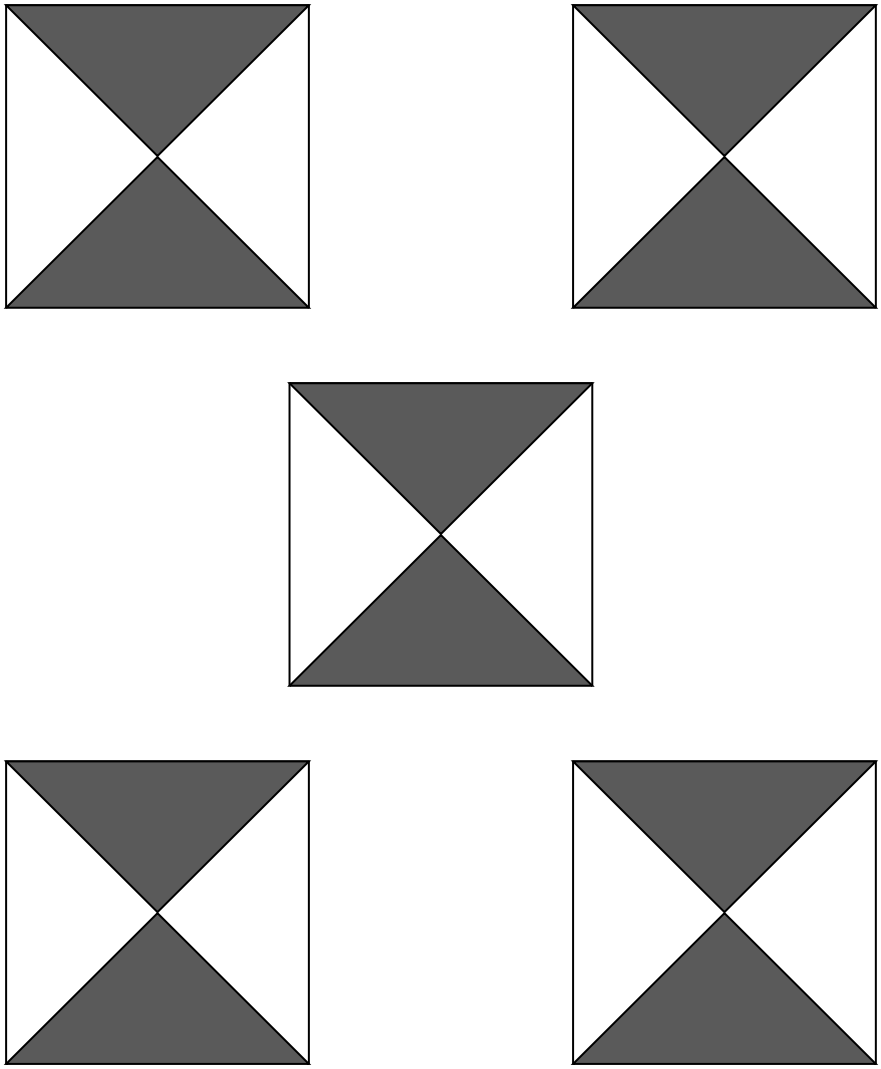
Depending on the usage environment (camera field of view size), **enlarge and reduce.**

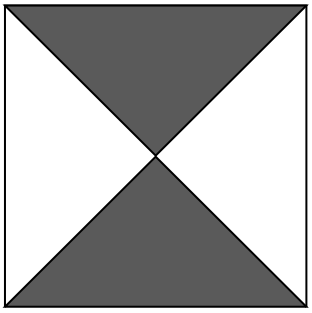


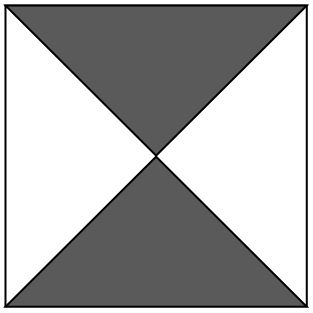
11.5. Calibration Sheet (For Contact type calibration)

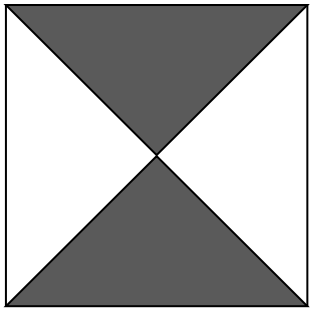
When performing the contact type calibration method, use the sheet as target marks.

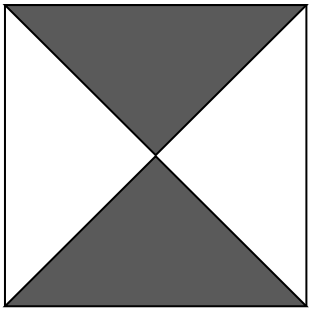
Depending on the usage environment (camera field of view size), **enlarge and reduce.**
If the configuration varies often, **placing separate marks may be useful**.

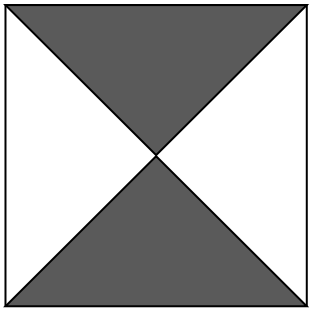












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