KEYENCE

972GB

Intuitive Vision System

CV-X Series 3D Vision-Guided Robotics System Easy Installation Guide

This installation guide supports the operations of connecting the CV-X480D (herein referred to as the CV-X Series) to the robot; configuring search, grip, and path settings; and operating the operation program of the robot.

- All damages, including secondary damages (such as equipment damage, opportunity loss, and lost profit) arising from the settings and programs introduced in this manual, are not covered by the warranty.
- You have to separately create robot operation programs such as those used during actual operation.
- The contents of this manual may be changed without notice in the interest of improving the manual.

Introduction

Symbols

The following symbols are used in this manual to enable the recognition of important information at a glance. Be sure to read these messages carefully.

DANGER	**Indicates a hazardous situation which, if not avoided, will result in death or serious injury.**
WARNING	**Indicates a hazardous situation which, if not avoided, could result in death or serious injury.**
CAUTION	**Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.**
NOTICE	**Indicates a situation which, if not avoided, could result in product damage as well as property damage.**

Important **Indicates cautions and limitations that must be followed during operation.**

Point **Indicates error-prone operating procedures.**

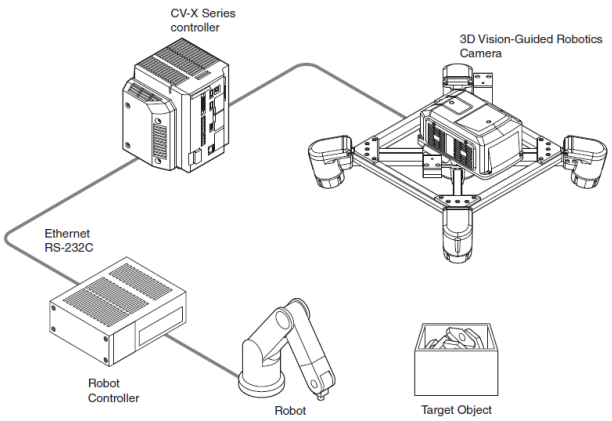
Reference **Indicates items that help enhance system understanding and other useful information.**

🕮 Indicates items and pages in this manual being referenced.

Overview

Using the CV-X Series 3D Vision-Guided Robotics system enables you to output the position and attitude of the robotic hand for gripping objects as robot coordinates from the CV-X Series controller to the robot controller. Objects in a box or loaded in bulk can be picked up and placed easily.

<During the setting phase>
Directly connect the CV-X Series controller to the robot controller and make preparations (perform calibration and so on) in order to output the object's grip position as robot coordinates.



<During the operation phase>
Configure output and other such settings according to the system configuration during the operation phase.
🕮 “Chapter 6 Operation Preparation”

Items to Prepare

The items to prepare before using the CV-X Series 3D Vision-Guided Robotics system in picking and placing applications are listed below.

☐ Ethernet cable or RS-232C cable

☐ Robot Vision Setup Program
* This is the robot program for communicating between the robot and the CV-X Series.

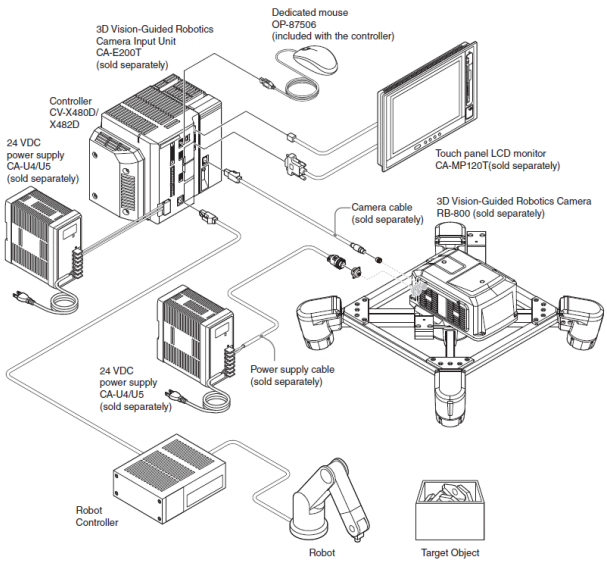
☐ “Vision-Guided Robotics System Robot Connection Manual”

Reference **You can download Robot Vision Setup Program and the 🕮 “Vision-Guided Robotics System Robot Connection Manual” from the “Vision-Guided Robotics System User Support Site” on the KEYENCE website.**

☐ Camera calibration target
(For RB-500: OP-88216; for RB-800/1200: OP-88217)

☐ Robot calibration target
(You can also use products other than the options made by KEYENCE, but we recommend that you use the OP-88218 to maximize the performance of this unit.)

Other peripheral equipment that is required in order to use the CV-X Series is shown below.



Safety Information

The purpose of this product is to assist in setting up the robot operation. This product does not guarantee the safe operation of the robot. Furthermore, the movement path of the robot that is output by this product can result in movement different than what is expected.
Users of this product must read and understand this "Safety Information" section and assume the responsibility that appropriate measures are taken to ensure the safe operation of the end product that incorporates the robot, regardless of the normal or abnormal operation of this product.

EXCEPT IN THE CASE OF AN INTENTIONAL ACT OR THE GROSS NEGLIGENCE OF KEYENCE, KEYENCE ASSUMES NO RESPONSIBILITY WHATSOEVER FOR ANY DIRECT OR INDIRECT DAMAGE OR LOSS TO THE USER OR A THIRD PARTY OF THIS PRODUCT REGARDLESS OF THE REASON FOR THE CLAIM.

Precautions on the Robot Operation

DANGER	・For the industrial robot connected to the CV-X Series with vision-guided robotics, those who install the industrial robot must perform a risk assessment for that machine to make an adequate risk reduction. ・The industrial robot connected to the CV-X Series with vision-guided robotics must comply with the requirements of ISO 10218-1 and ISO 10218-2. ・Those who operate the industrial robot through the CV-X Series vision-guided robotics must be trained according to the applicable laws, rules, regulations, and standards in the country or region where the industrial robot is installed. ・The manual reduced speed mode must be used for jogging, teaching, programming, and program verification of the industrial robot. The speed of the industrial robot must be 250 mm/s or less under this mode.

General Cautions

DANGER	・Do not use this product for the purpose of protecting the human body or any part thereof. ・This product is not intended for use as an explosion-proof product. Never use this product in a hazardous location and/or potentially explosive atmosphere.
CAUTION	・You must verify that this product is operating correctly in terms of functionality and performance before the start and the operation of this product. ・We recommend that you take substantial safety measures to avoid any damage in the event of a problem occurring.
NOTICE	・Do not modify this product or use it in any way other than described in the specifications. The functions and performance of products used or modified in this way cannot be guaranteed. ・When this product is used in combination with other instruments, functions and performance may be degraded, depending on the operating conditions and surrounding environment.

Contents

Chapter 1 Operation Flow

This chapter explains the operation flow from connecting the CV-X Series controller (hereinafter referred to as the "CV-X") to the robot controller to outputting in robot coordinates the position where the object detected by the CV-X is gripped.

Point **To perform robot vision setting operations, "Robot Vision Setup Program" must be running on the robot controller. Before performing "2. Creating 3D Vision-Guided Robotics Settings," be sure to complete the operations given under "2. Robot Communication Settings" by referring to the 🕮 "Vision-Guided Robotics System Robot Connection Manual."**

Reference **If you are using the path planning tool described in this manual, you have to use a CV-X with version 5.2 or later. You can download the latest firmware for the controller, "Robot Vision Setup Program," and the 🕮 "Vision-Guided Robotics System Robot Connection Manual" from the "3D Vision-Guided Robotics System User Support Site" on the KEYENCE website.**

1. Installing the Controller/Camera 🕮 "Chapter 2"	Install the CV-X and the 3D vision-guided robotics camera and connect the necessary devices.
2. Creating 3D Vision-Guided Robotics Settings 🕮 "Chapter 3"	Create a program setting for 3D Vision-Guided Robotics, and then change the camera settings and calibrate the camera so that images can be captured correctly.
3. Connecting to the Robot 🕮 "Chapter 3"	Establish a connection by using the communication program (Robot Vision Setup Program). Calibrate the robot and align the coordinates and axis orientations.
4. Configuring the Settings for Searching for the Object (3D Search) 🕮 "Chapter 4"	Register the model of the object or the box containing the object (or the plane on which the object is placed) and configure the settings for searching.
5. Configuring Object Grip Settings (Path Planning to Grip Registration) 🕮 "Chapter 5"	Set the grip position for the registered search model and the approach and departure operations that correspond to this grip position.
6. Setting the Operation Path (Path Planning to Path Settings) 🕮 "Chapter 5"	From the models of the robot and the hand, the object grip position, and the layout, judge collisions with the surrounding obstacles and calculate the operation path with minimum attitude changes.
7. Operation Preparation 🕮 "Chapter 6"	Change the output settings used during the operation phase and prepare the robot-side program.

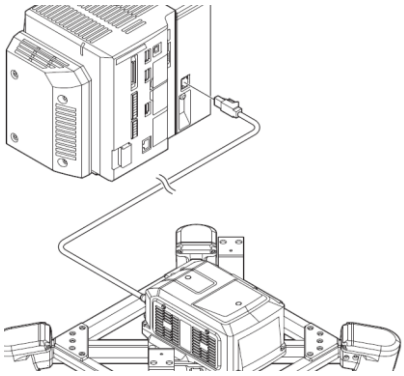
Chapter 2 Device Installation

Attach to the CV-X and install the devices that are required to use the vision-guided robotics system.
For details, see the "CV-X Series User's Manual (3D Vision-Guided Robotics Edition)."

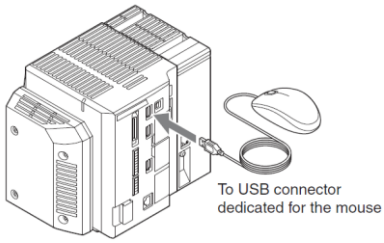
NOTICE	**Be sure to turn the power off before connecting the connectors and terminals.**

2-1 Installing the Controller

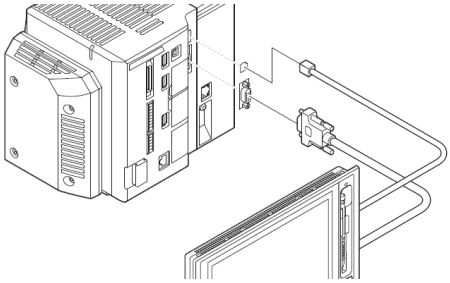
☐Connect the 3D vision-guided robotics camera.



☐Connect the mouse.

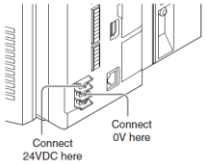


☐Connect the monitor.



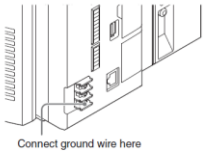
☐Connect the power supply and the ground wire (controller, camera input unit).

1. Connect 24 VDC and 0 V to the power terminals.



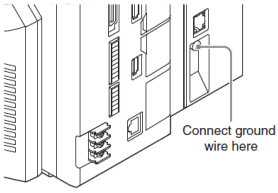
NOTICE	**Do not connect the 0 V of the power terminal to the ground terminal or the ground wire.**

2. Connect the ground wire to the grounding terminal.



Connect the ground wire to the grounding terminal.

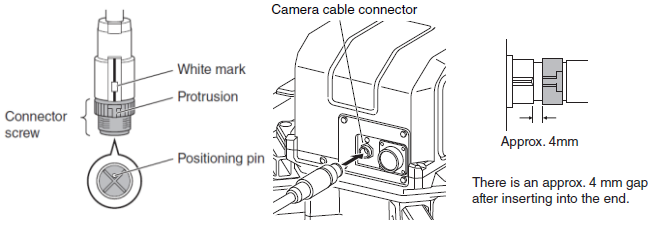
Reference	As power is supplied directly from the controller, the camera input unit does not need to be connected to a power source.



2-2 Installing the 3D Vision-Guided Robotics Camera

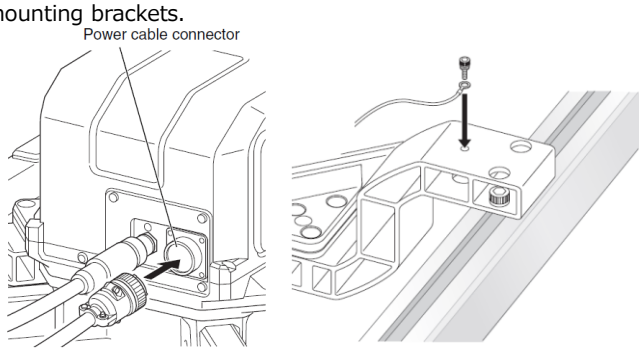
☐Connect the camera cable.

Align the position of the protrusion on the connector screw of the cable with the position of the white mark on the controller connector, and then insert the connector in a straight manner so that it is not at an angle.



☐Connect the power supply and the ground wire.

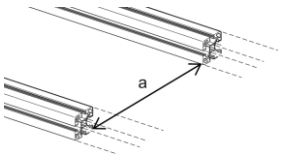
Align the power cable with the connector guide, and then insert the cable in a straight manner so that it is not at an angle. Connect the ground wire to one of the main unit mounting brackets.



☐Installing at the facility

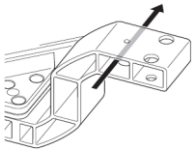
Place wires on the left and right main unit mounting brackets, and then lift the mounting brackets up to the height of the installation location with the mounting brackets parallel with each other so that they can pass through the installation location. After passing the brackets through the installation location, rotate the main unit 90 degrees, place the main unit mounting brackets on top of the installation location, and then secure the main unit with the included mounting bolts.

Point	**We recommend an aluminum frame of size 40 × 40 as an installation location that supports the main unit mounting brackets. The inside - inside dimension (a in the following figure) is 412 mm (common to all models).**

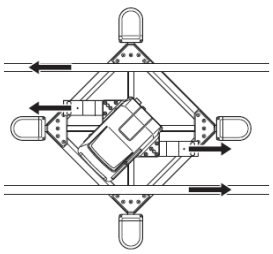


In order to lift the unit during installation, attach wires on both sides of the main unit mounting brackets.

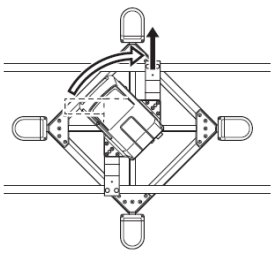
NOTICE	**Do not attach the wire to any location other than the main unit mounting bracket. Otherwise, it may cause deformation or damage.**



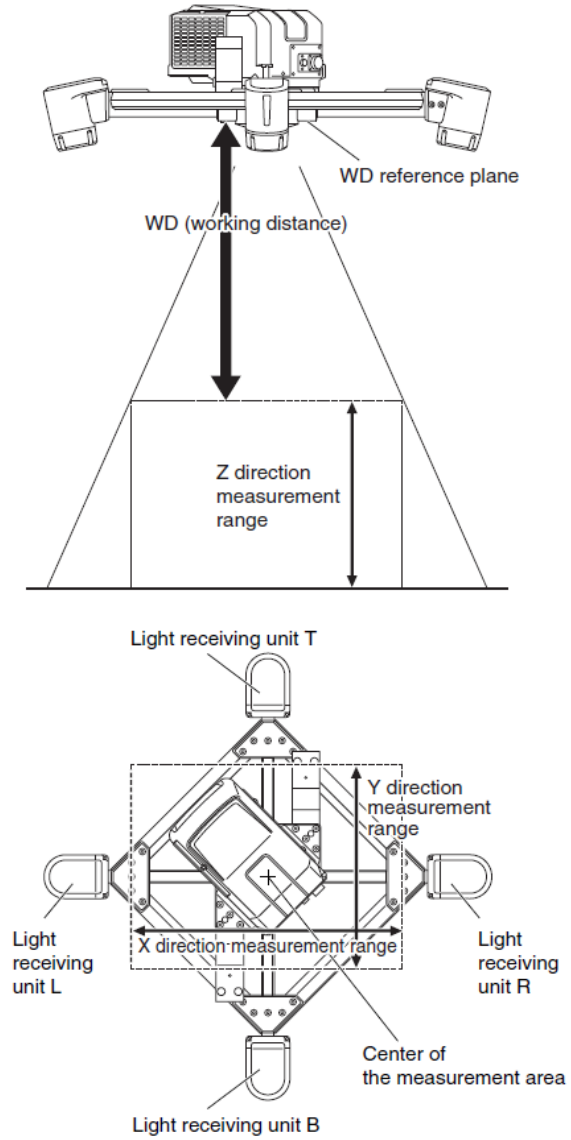
· When lifting



· When installing



☐Measurement range



Point **The direction of the image captured by the unit is upward in the direction of light receiving unit T and cannot be changed after installation. Install the unit so that the image does not become different from the intended direction. An identification seal is affixed to the arm of light receiving unit T when shipped from the factory.**

Model	X (mm)	Y (mm)	Z (mm)	WD
RB-500	520	390	200	1500
RB-800	860	645	500	1700
RB-1200	1260	1260	1000	2000

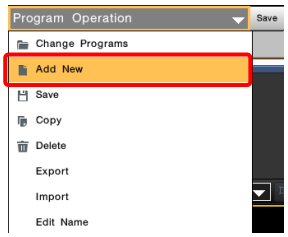
Chapter 3 Creating Settings

Add new 3D vision-guided robotics settings to the CV-X, and then configure the camera settings and communication settings.

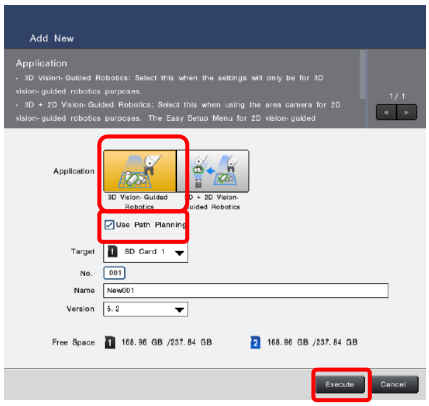
Reference **When creating settings with the simulator, it is only necessary to configure the settings in section 3-1 and to load the robot model data, which is the last item in section 3-3. No other settings are required.**

3-1 Add New

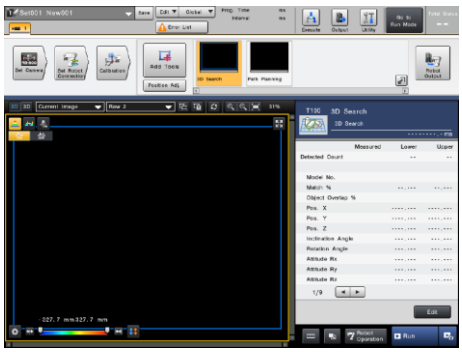
1. Click Set000 New000 in the upper-left corner of the screen and select [Add New] from the [Program Operation] menu that is displayed.



2. Select [3D Vision-Guided Robotics] for [Application], select the [Use Path Planning] check box, and then left-click [Execute].



Reference **If you are using the conventional 3D Pick tool without using the Path Planning tool, start the system without selecting the [Use Path Planning] check box.**

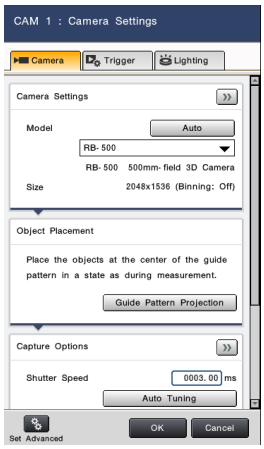


The new settings will be created. [3D Search] and [Path Planning] are preregistered. By default, follow the operations as shown in the upper-left corner of the screen: [Set Camera], [Set Robot Connection], and then [Calibration].

3-2 Camera Settings

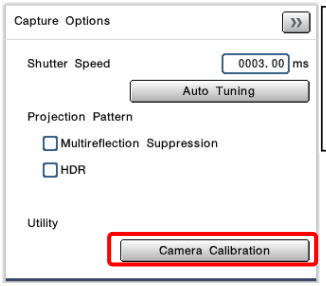
1. Left-click Set Camera in the upper-left corner of the screen.

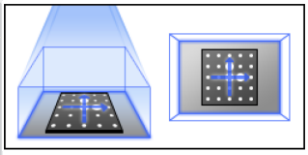
The [Camera Settings] screen appears.



2. Left-click [Camera Calibration] under [Utility] in the [Capture Options] field.

Wait until [Warm-up Information] changes to [Done] (warming up normally takes about 60 minutes), and then proceed to step 2. Place the camera calibration target at the bottom of the space that you want to measure and detect the target. Proceed to step 3, place the camera calibration target at the top of the space that you want to measure, and then left-click [Execute Calibration].
The calibration data is calculated from the two detection results.





Reference **Multireflection Suppression:**
Selecting this check box increases the number of projection pattern types, improving durability against captured glare. This is effective for glossy objects and boxes.
HDR:
Images are captured with two shutter speeds, thereby interpolating the three-dimensional measurement. This is effective when viewing different materials at the same time.

3. Left-click [Guide Pattern Projection] in the [Object Placement] field.

Place the objects at the center of the lit guide pattern in a state as during measurement, and then left-click [Stop] when you are done.

4. Left-click [Auto Tuning] in the [Capture Options] field.

The [Auto Tuning] screen appears. Match the area to the size of the box, and then left-click [Execute] to automatically set the shutter speed.

To perform additional fine-tuning, left-click ».

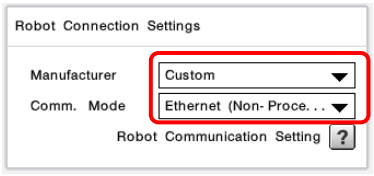
3-3 Robot Connection Settings

Point **Be sure to run "Robot Vision Setup Program" on the robot controller before you perform operations. For details, see the "Vision-Guided Robotics System Robot Connection Manual."**

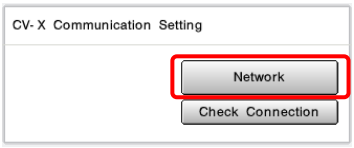
1. Left-click  in the upper-left corner of the screen.

The [Robot Connection Settings (Global)] screen appears.

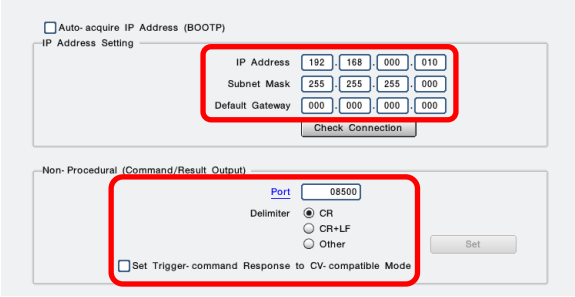
2. Select the [Manufacturer] and [Comm. Mode] settings under [Robot Connection Settings].



3. Left-click [Network] or [RS-232C] under [CV-X Communication Setting].



Configure the settings under [IP Address Setting] and [Non-Procedural (Command/Result Output)] for the CV-X. Unless you need to change these settings, leave them as their default values and proceed to the next step.

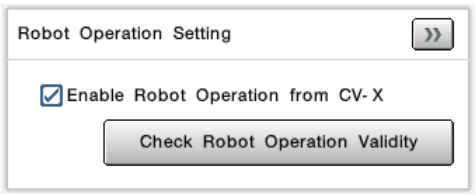


Point

- **Do not enter the IP address of the robot controller.**
- **Ensure that the CV-X and the robot controller do not have the same IP address.**
- **Set [Delimiter] to [CR] and clear the [Set Trigger-command Response to CV-compatible Mode] check box.**

Reference **If a message prompting you to restart the CV-X is displayed, restart the CV-X.**

4. Under [Robot Operation Setting], select the [Enable Robot Operation from CV-X] check box (it is selected by default when the product is shipped from the manufacturer), and then left-click [Check Robot Operation Validity].

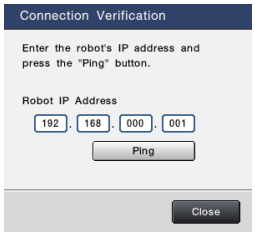


When a message confirming that "Robot Vision Setup Program" is running appears, the check is complete.

Important **If "Robot Vision Setup Program" is not running on the robot controller, you will not be able to execute the [Check Robot Operation Validity] operation.**

Reference

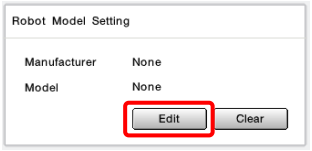
- **If you cannot use an Ethernet connection to check the connection, use [CV-X Communication Setting] > [Check Connection] to do so, and then revise the settings and check the connection cable.**

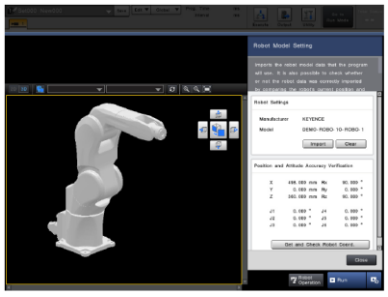


- **If you do not want to operate the robot from the CV-X, do not select the [Enable Robot Operation from CV-X] check box.**

5. Left-click [Edit] under [Robot Model Setting] (when using the Path Planning tool).

The [Robot Model Setting] screen appears.
Click [Import] under [Robot Settings] to read the robot model data provided by KEYENCE. The information registered here is used by the Path Planning tool.





Point **Left-click [Get and Check Robot Coord.] to check both the current coordinates and the coordinates calculated from the robot model data that was loaded. If the data is correct, the coordinates will match almost perfectly, so check that there is no difference between them.**

3-4 Robot Calibration

Point **Be sure to run "Robot Vision Setup Program" on the robot controller before you perform operations. For details, see the "Vision-Guided Robotics System Robot Connection Manual."**

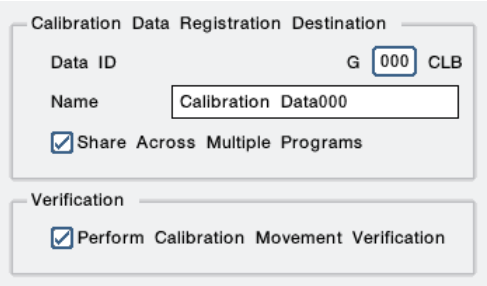
1. Left-click  in the upper-left corner of the screen.

The [Calibration] screen appears.

2. Left-click [Add].

Set the [Data ID] and select the [Share Across Multiple Programs] and [Verify Robot Action in Advance] check boxes, and then left-click [OK].

Reference **The explanations given in this guide assume that the [Verify Robot Action in Advance] function is enabled.**
For details on the operations when the [Verify Robot Action in Advance] function is disabled, see the "CV-X Series User's Manual (3D Vision-Guided Robotics Edition)."

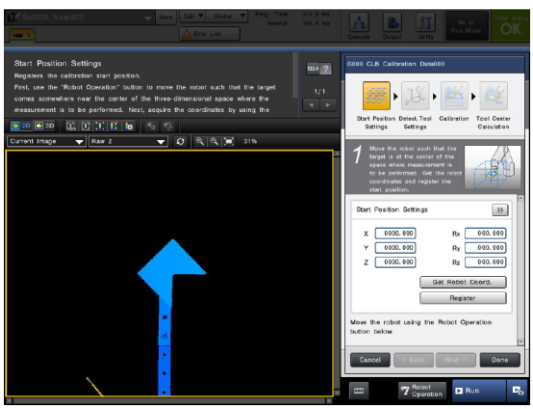


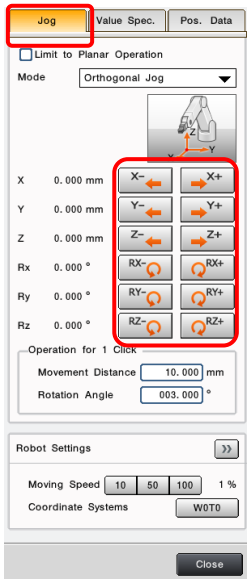
The settings screen for the calibration data appears.

3. [Start Position Settings] Move the robot to register the calibration start position.

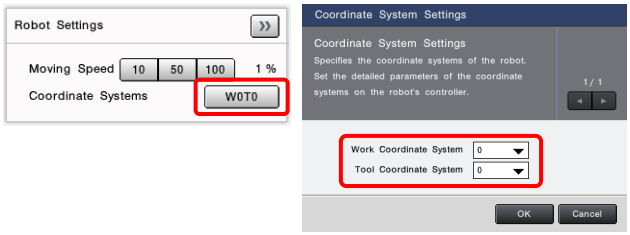
Attach the calibration target (OP-88218), and then use jog operations to move the target's position so that the target is in the center of the space that is going to be measured.

DANGER	**・ This operation sets the robot into motion. The operator needs to have completed specialized training.** **・ Make sure that the operation can be stopped immediately using the emergency stop switch in the event of a failure.**



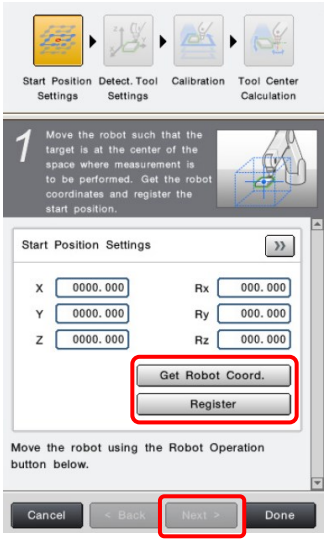


At this time, click the button next to [Coordinate Systems] and check that the [Work Coordinate System] and [Tool Coordinate System] numbers to use are correct.



Reference
・ If you hold down a movement button, the robot will continue operating continuously.
・ If you attempt to move the robot outside of its movable range, an error may occur depending on the robot.

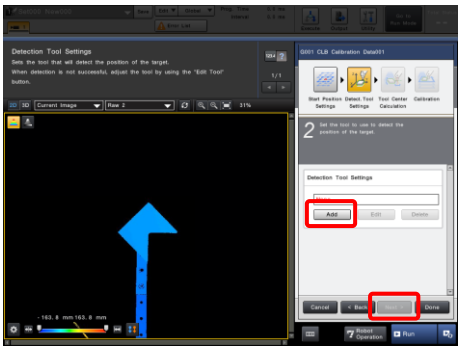
Left-click [Get Robot Coord.] to display and store the details of the obtained robot coordinates. Left-click [Register] to register the coordinates as the calibration start position. Left-click [Next] to proceed to the [Detection Tool Settings].



4. [Detection Tool Settings] Configure the [3D Search for Calibration] settings.

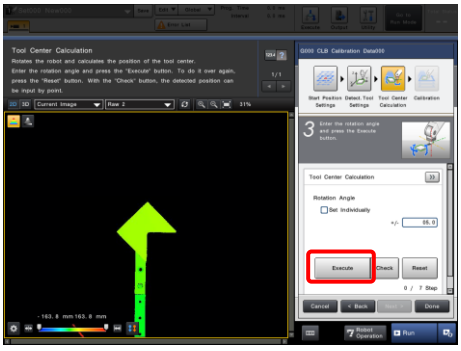
When you left-click [Add] in the [Detection Tool Settings] field, [3D Search for Calibration] is added, so configure the settings for [3D Search for Calibration].

Point **The Vision-Guided Robotics Calibration Target (OP-88218) is used in the calibration, so a search model is registered automatically from the CAD data included with the device.**



When you are finished configuring the [3D Search for Calibration] settings, left-click [Done], and then left-click [Next] in the [Detection Tool Settings] field.

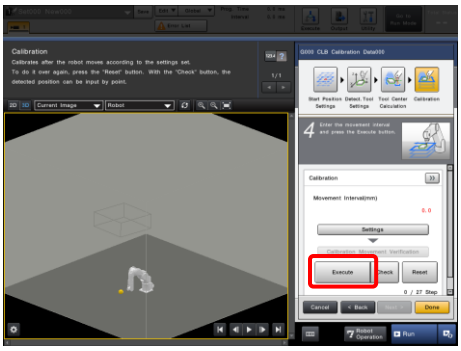
5. [Tool Center Calculation] Set [Rotation Angle] to the hand rotation angle, and then left-click [Execute].



A tool center calculation execution confirmation message appears. Left-click [OK]. The image capture and movement are repeated, so once the operations are complete and a message that indicates so appears, left-click [Close] then [Next].

DANGER	**・This operation sets the robot into motion. The operator needs to have completed specialized training.** **・Make sure that the operation can be stopped immediately using the emergency stop switch in the event of a failure.**

6. [Calibration] Set the movement pattern, and then left-click [Execute].



Reference **Left-click » to configure advanced settings for calibration. For details, see the "CV-X Series User's Manual (3D Vision-Guided Robotics Edition)."**

A message appears asking you to confirm that you want to execute calibration. Left-click [OK]. The image capture and movement are repeated. Once the operations are complete, a message that indicates so appears.

DANGER	**・This operation sets the robot into motion. The operator needs to have completed specialized training.** **・Make sure that the operation can be stopped immediately using the emergency stop switch in the event of a failure.**

Point **If calibration fails, check the robot attitude at the start position, the movement interval, and the detection tool settings. Then execute calibration again.**

Chapter 4 3D Search Settings

The 3D Search tool detects the object's position and attitude three-dimensionally. By extracting feature points from the three-dimensional shape (height image) of the object surface and matching those feature points to the information of the captured image, the object's position and attitude can be identified.

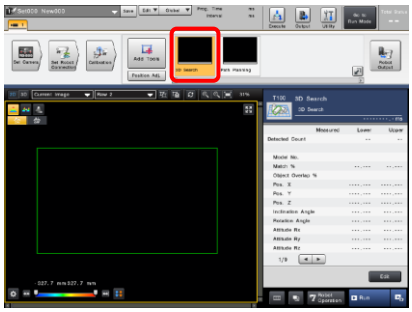
4-1 Model Registration

In order to extract feature points on an object surface shape, register the CAD data for the object to detect or the image captured with the 3D Vision-Guided Robotics camera as a search model.

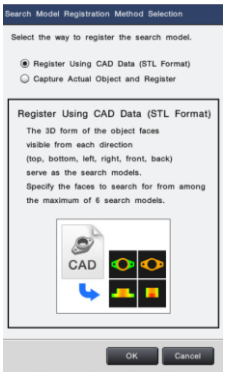
When registering from CAD data (STL format)

Point **The CAD data to be read must be in STL format and have a size of 25 MB or less.**

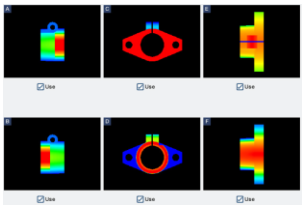
1. On the toolbar on the settings screen, double-click the [3D Search] tool.

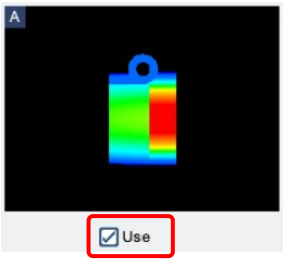


2. Select [Register Using CAD Data (STL Format)], and then left-click [OK].



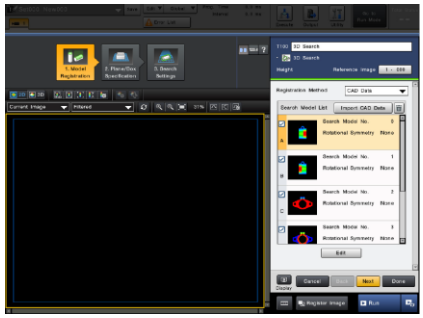
Select the CAD data for the object, and then left-click [Import]. The [Search Model Selection] screen appears. Clear the [Use] check box for any models that you do not want to search for.





3. Left-click [Close].

The models registered to the [Search Model List] are displayed in the list. Left-click [Run] to check whether the search can be performed correctly. If there are no problems, the search model registration is complete. Left-click [Next] to proceed to [Plane/Box Specification].

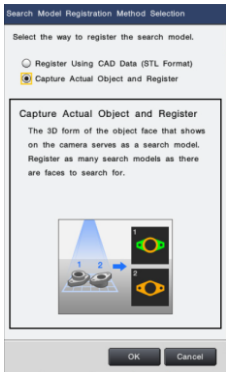


When capturing and registering an actual object

Point **If the shutter speed needs to be adjusted to match the object detection, perform automatic adjustment with the same procedure as in 3-2 "Camera Settings" while capturing the object.**

1. On the toolbar on the settings screen, double-click the [3D Search] tool.

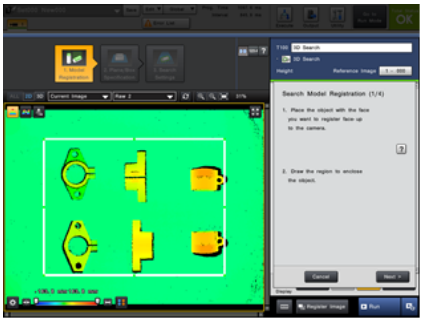
2. Select [Capture Actual Object and Register], and then left-click [OK].



The [Search Model Registration (1/4)] screen appears.

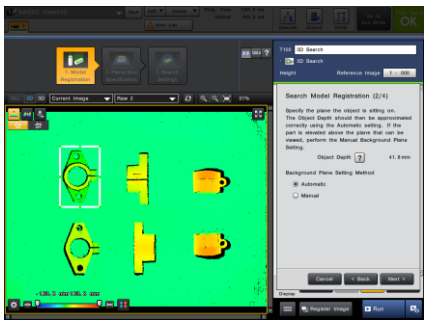
3. Follow the on-screen instructions to place/capture the object and specify the model region so that it encompasses the image to be registered as a search model.

Point **When registering an object, placing it on a flat surface with the object's frequently occurring attitude and height and capturing an image of the object makes it easy to configure more stable settings.**



Left-click [Next] to proceed to [Search Model Registration (2/4)].

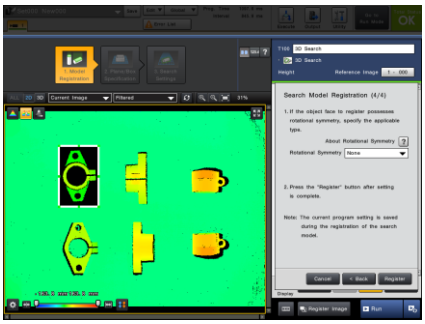
4. Set the background plane such that object depth will be correct.



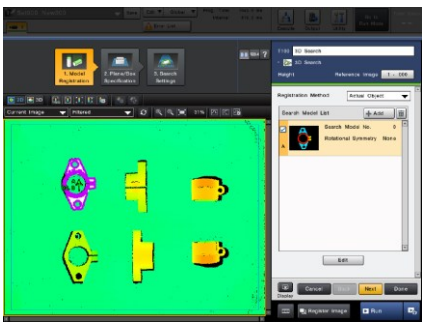
Left-click [Next] to proceed to [Search Model Registration (3/4)].

5. If necessary, follow the on-screen instructions to set the [Background Cut] and [Mask Region], and then left-click [Next].

6. If the search model to register has a shape with rotational symmetry, set the [Rotational Symmetry]. When the setting is complete, left-click [Register].



The search model that was registered to the [Search Model List] is displayed.



7. To register other search models, left-click [Add] and repeat the registration procedure.

Left-click [Run] to check whether the search can be performed correctly. If there are no problems, the search model registration is complete. Left-click [Next] to proceed to [Plane/Box Specification].

4-2 Plane/Box Specification

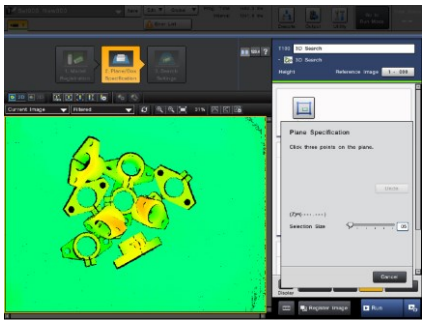
Specify the plane that the object is placed on or the box that the object is in. You can limit object misdetections with the plane and box information and also use this information in judging collisions with the robot.
Register the information with the [Plane], [Box (Fixed)], [Box (Track)], or [Box (Track by 2D)] option.

Reference **If the box that contains the object moves, select [Box (Track)] Also, if it is difficult to detect the height information of the box, such as for wire mesh pallets, select [Box (Track by 2D)]. Using the fixed setting instead of a tracking setting reduces the processing time by the amount of time that searching is not performed.**

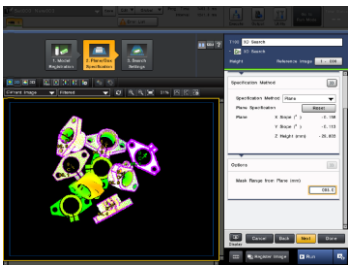
Plane

1. Select [Plane] for [Specification Method], and then left-click [Next].

The [Plane Specification] screen appears. Specify the [Selection Size], and then click three points on the screen to specify the plane.



2. If there are undulations on the floor face, set [Mask Range from Plane (mm)] higher than the height of the undulations to eliminate noise from the undulations.

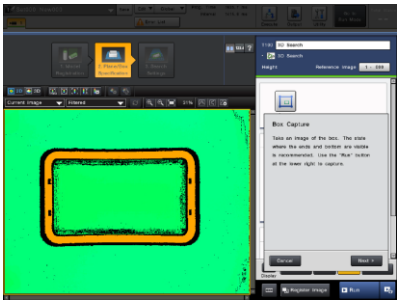


Left-click [Next] to proceed to the [Search Settings].

Box (Fixed)

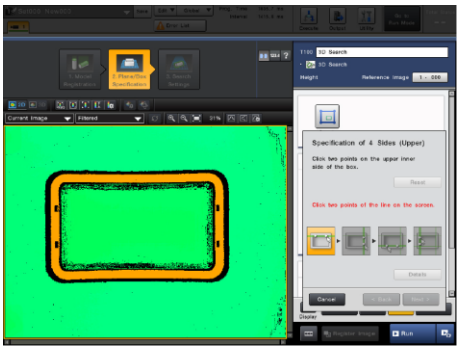
1. Select [Box (Fixed)] for [Specification Method], and then left-click [Next].

Follow the on-screen instructions to capture an image of an empty box, and then left-click [Next].

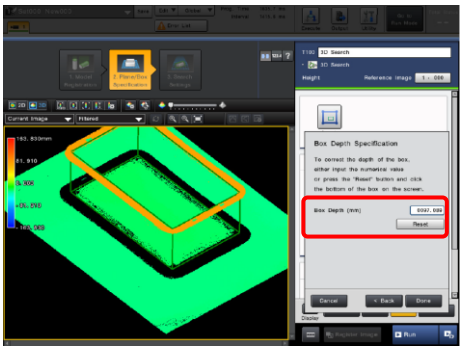


2. Select the [Box Specification Method], and then left-click [Next].

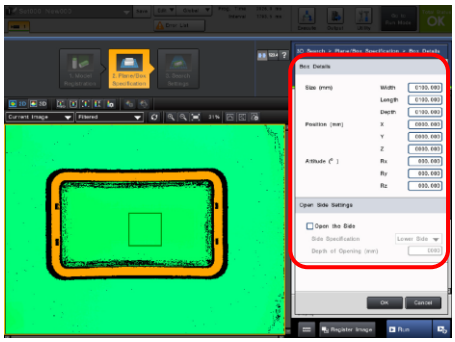
If you select [Specify the 4 Sides of the Box], follow the on-screen instructions to specify the four sides of the box on the image.



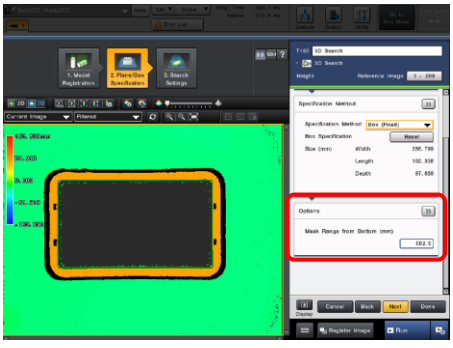
The [Box Depth Specification] screen appears.
The [Box Depth (mm)] is automatically set from the image height information (the value can also be corrected).



When [Specify the Position and Size Values] is selected, enter the values for each item. To use a box with a side open, enter the information that is necessary for the [Open Side Settings], and then left-click [OK].



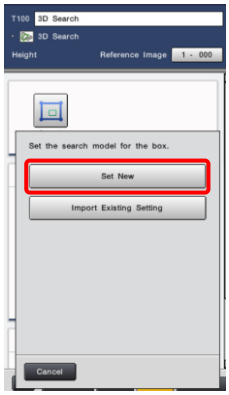
The box data is registered and the [2. Plane/Box Specification] screen appears. If there are undulations on the base of the box, set the [Mask Range from Bottom (mm)]. When the settings are complete, left-click [Next] to proceed to the [Search Settings].

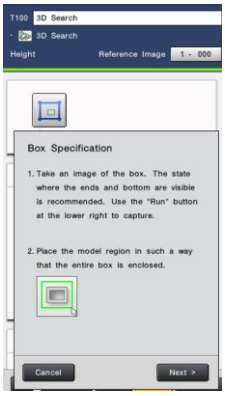


Box (Track)

1. Select [Box (Track)] for [Specification Method], and then left-click [Next].

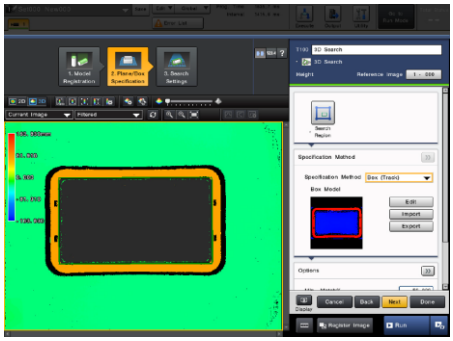
The [Set the search model or the box.] screen appears. Left-click [Set New]. The [Box Specification] screen appears. Capture an image of an empty box and specify the model region so that it encloses the entire box.
You can also import a model of a box that has already been created by left-clicking [Import Existing Setting] and specifying a file in the [Import] dialog box.



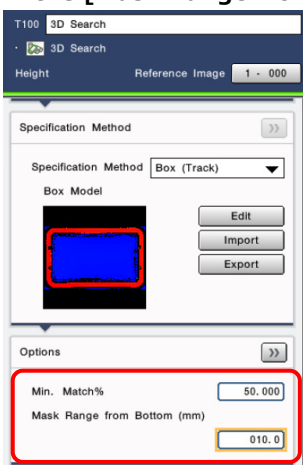


2. Left-click [Next].

The [Box Specification Method] screen appears.
In the same manner as [Box (Fixed)], specify the four sides or the size and other such numeric values, and then left-click [OK].
The box search model is registered and the [2. Plane/Box Specification] screen appears.



3. Set the minimum match value for when searching for the created box search model and the [Mask Range from Bottom (mm)].



Left-click [Next] to proceed to the [Search Settings].

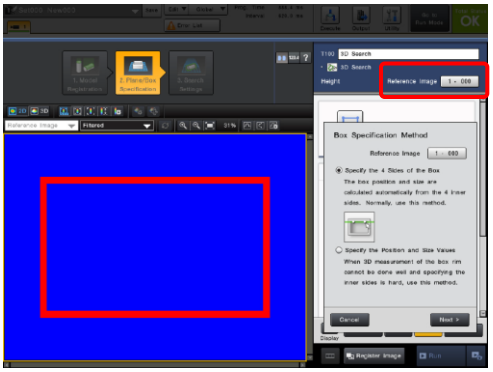
Box (Track by 2D)

Point

- **Only tracks positional shifts in the XY plane.**
- **[Box (Track by 2D)] is set on the basis of the reference image.**
  Register an empty box as the reference image in advance in [Reference Image Registration].
- **Add the tool to be used for the position adjustment in advance on the main screen.**

1. Select [Box (Track by 2D)] for [Specification Method], and then left-click [Next].

The [Box Specification Method] screen appears.
Select a reference image of the captured empty box with [Reference Image].

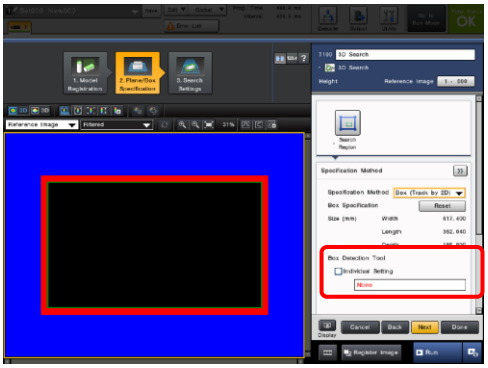


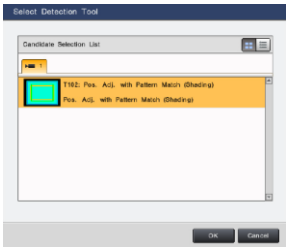
2. Select the [Box Specification Method], and then click [Next].

In the same manner as [Box (Fixed)], specify the four sides or the size and other such numeric values, and then left-click [OK].
The box data is registered and the [2. Plane/Box Specification] screen appears.

3. Left-click [Box Detection Tool].

Position adjustment tools that have been added beforehand will appear on the [Select Detection Tool] screen (if the tool to be used has not been added, return to the main screen and add it). Select the detection tool for tracking the box position, left-click [OK], and then configure the search settings.



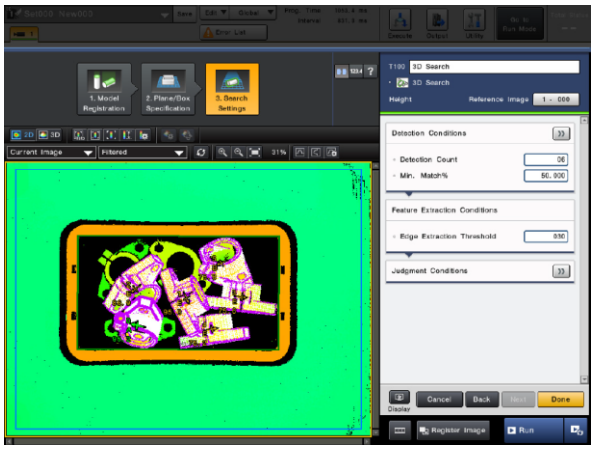


Left-click [Next] to proceed to the [Search Settings].

4-3. Search Settings

Use the search models that you registered in [Model Registration] and set the conditions to search for objects in the region specified in [Plane/Box Specification].

1. In the [Detection Conditions] field, set the conditions for detecting the objects.



Detection Count: Maximum number of objects to be detected.
Min. Match%: Objects with Match% values lower than this value will not be detected.
Edge Extraction Threshold: Threshold for the edge intensity to be detected as a shape.

2. If necessary, click [»] in the [Judgment Conditions] field and set the judgment conditions for the detected search model.

Reference

Left-click [»] to configure advanced settings. For details, see the "CV-X Series User's Manual (3D Vision-Guided Robotics Edition)."

3. Once you have completed the settings, left-click [Done].

The search settings are registered, and the settings screen reappears.
This completes the [3D Search] settings.

Chapter 5 Path Planning

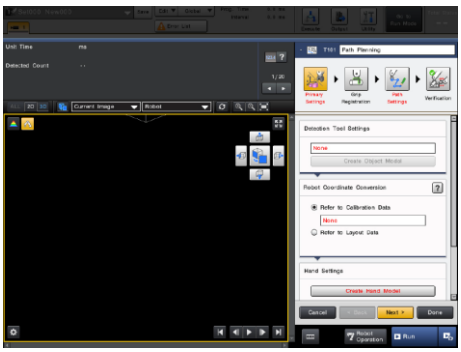
The Path Planning tool is used to set the path on which the robot moves to grip objects detected with the 3D Search tool and moves to the target position.

5-1 Primary Settings

In the primary settings, enter the information required to accurately judge collisions with the surrounding area when creating a path. Specify the tool to use in detecting the object, specify the calibration data used in conversions to robot coordinates, register the model of the hand that will be used for gripping, and set the layout of items such as the box in which to insert the object and the obstacles around the robot.

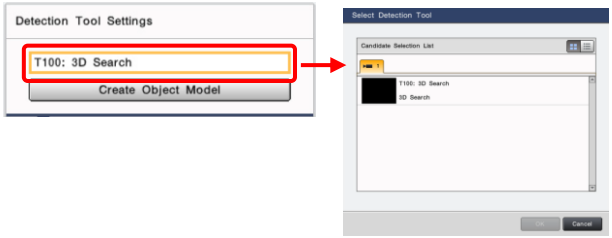
1. Double-click the [Path Planning] tool.

The [Primary Settings] screen appears.

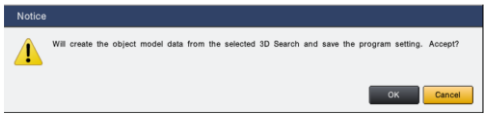


2. Left-click the [Detection Tool Settings] field.

The [Select Detection Tool] screen appears.
Select the [3D Search] tool for detecting the object, and then left-click [OK].



A message appears asking you to confirm that you want to create model data.
Left-click [OK].

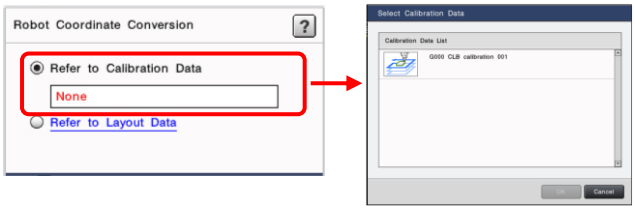


Point

- **The object model is outer appearance data that is used in collision judgment.**

3. Select the data that specifies the positional relationship between the robot and camera.

When referencing calibration data, select the corresponding data on the [Select Calibration Data] screen, and then left-click [OK].



If there is no calibration data, select [Refer to Layout Data].

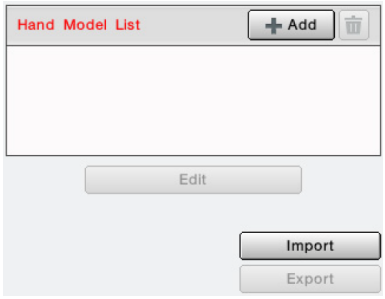
Point

Select [Refer to Layout Data] to enable you to use the [Layout Settings] to manually edit the position of the plane/box to use in placing the object.
This option is used during the verification phase before calibration is performed and therefore only operates in setup mode.

4. Left-click [Create Hand Model].

The [Hand Settings] screen appears.
Left-click [Add] to display the [Add] screen.

If any created hand models exist, you can left-click [Import] to import them.

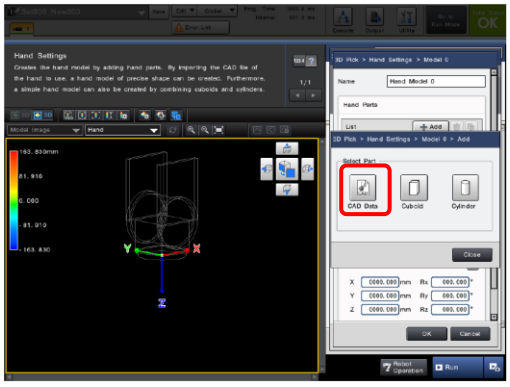


5. Select the type of part that you want to add to create a hand model.

To specify the hand model with CAD data, left-click [CAD Data]. The [Import CAD Data] screen appears. Select the corresponding data, and then left-click [Import].

Point

The CAD data to be read must be in STL format and have a size of 25 MB or less.

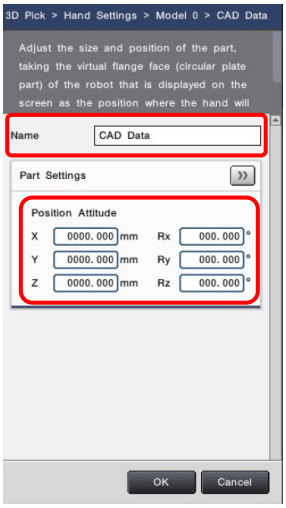


The [Collision Judgment Model Settings] screen appears in step format.
Set each step.

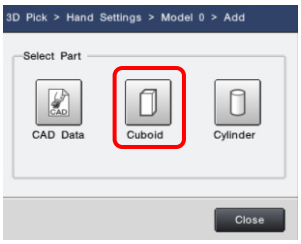
(Step 1) Select the surface to be attached to the flange of the robot.
(Step 2) Adjust the position and attitude of the hand such that it is just like the actual installation.
(Step 3) Select the direction in which the hand will approach the object.
(Step 4) Set the target to be judged if necessary.

After setting all the steps, click [Done].

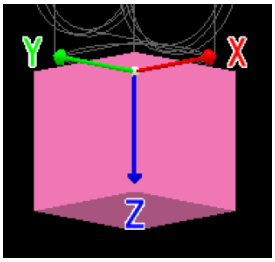
The [CAD Data] screen appears.
Set the [Name] and [Position Attitude] of the hand model, and then left-click [OK]. The hand model is added to the hand parts list.

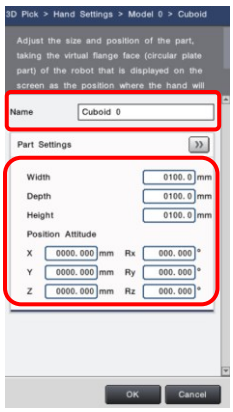


To specify the hand model using cuboids, left-click [Cuboid].

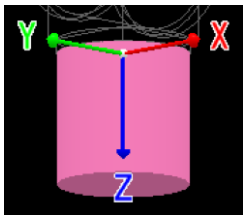


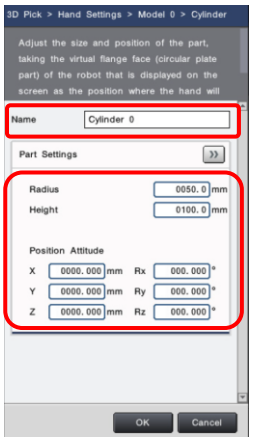
The [Cuboid] screen appears.
Set the [Name] and each size, and then left-click [OK].
The hand model is added to the hand parts list.





To specify the hand model using cylinders, left-click [Cylinder].
Set the [Name] and each size, and then left-click [OK].
The hand model is added to the hand parts list.

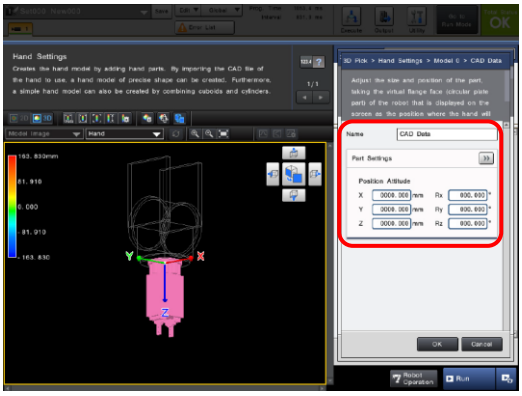




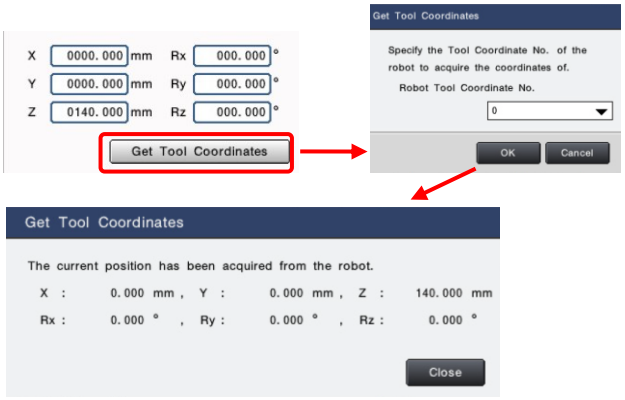
6. To create a hand model by combining [Cuboid] and [Cylinder], left-click [Add], and then repeat the above procedure.

7. Once you have added a hand model, set the tool coordinates for the added hand model in the [Tool Coordinates] field.

NOTICE	**In [Tool Coordinates], set the same coordinates as the tool coordinates on the robot. If the coordinates differ, the hand may collide with the object or the box, leading to damage.**



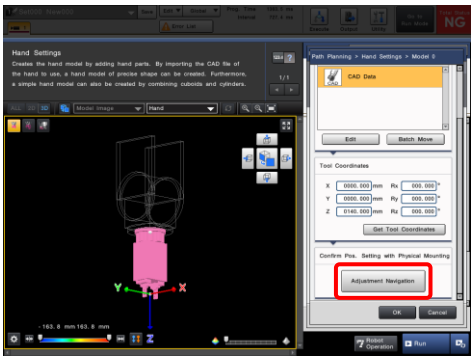
To acquire the robot's tool coordinates, ensure that Robot Vision Setup Program is running, left-click [Get Tool Coordinates], specify the tool coordinate number that you will use on the robot, and then left-click [OK].



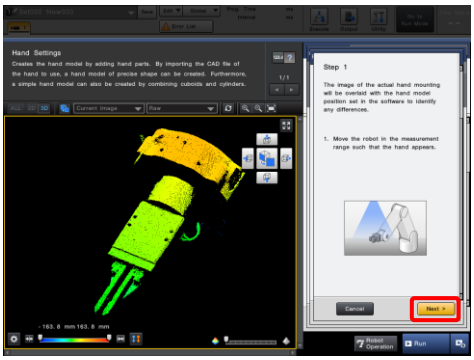
8. If necessary, reflect the amount of mounting deviation of the hand in the actual environment to the hand model settings (Tool Adjustment Navigation).

Point **[Tool Adjustment Navigation] uses CAD data for the hand parts and can be used if the robot calibration data is being referenced by the robot coordinate conversion.**

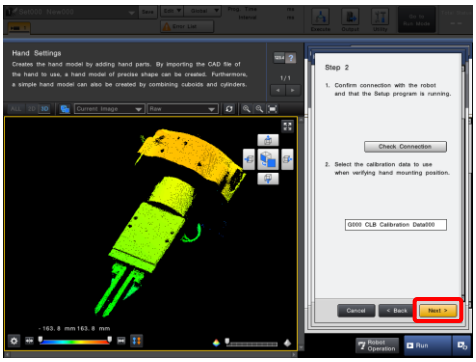
Left-click [Tool Adjustment Navigation] under [Actual Environment Adjustment].



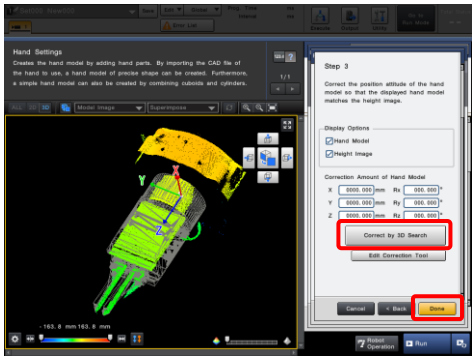
Following the on-screen instructions, move the robot in the measurement range such that the robot hand appears, and then left-click [Next].



Following the on-screen instructions, start the robot vision setup program and click the [Check Connection] button to check that the robot is connected.
Next, select the robot calibration data that you want to reference, and then left-click [Next].

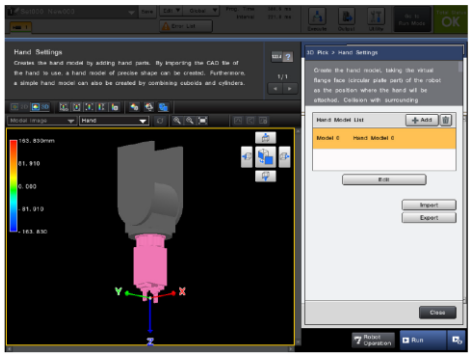


Correct the position attitude of the hand model so that the displayed hand model matches the hand height image.
Once you finish the correction, left-click [Done].



9. Left-click Click [OK].

A message appears asking you to confirm that you want to register the hand model.
Left-click [OK].
The hand model is registered and the [Hand Settings] screen reappears.

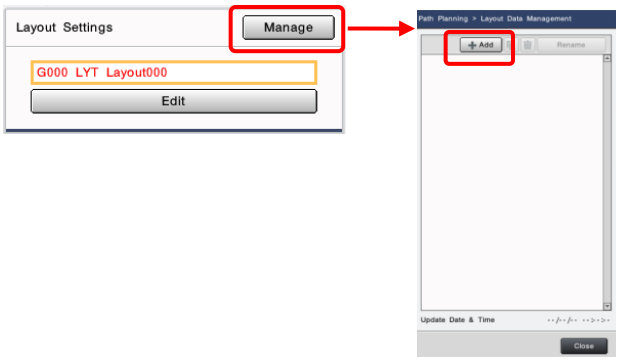


Left-click [Close] to return to the [Primary Settings] screen.

Reference **In this situation, if you capture an image of the hand part and select [Overlapped Display] on the camera screen, the image capture data and model data will both appear at the same time. This function is useful in checking for mistakes in the setting details.**

10. Left-click [Manage] in the [Layout Settings] field on the [Primary Settings] screen.

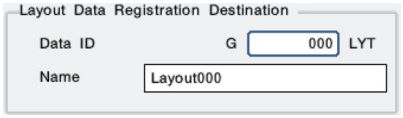
The [Layout Data Management] screen appears.
To create new layout data, left-click [Add].

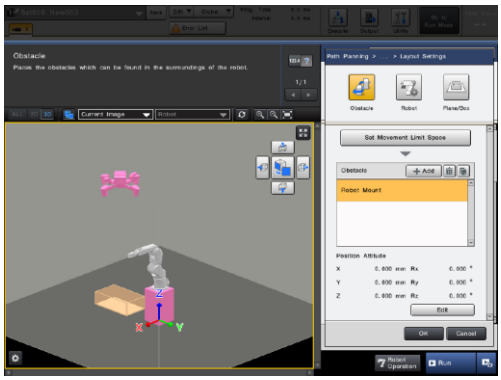


The [Add Layout Data] screen appears.

11. Set the [Data ID] and [Name], and then left-click [OK].

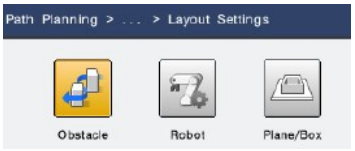
The [Layout Settings] screen appears.



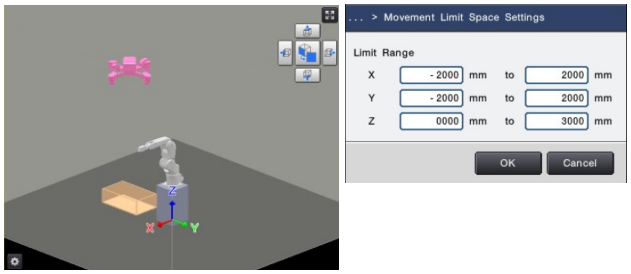


12. Switch between [Obstacle], [Robot], and [Plane/Box] and set the layout.

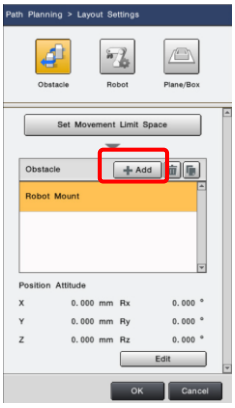
To set the positions and sizes of items around the robot (within its movement limit space) such as stands and pillars, left-click [Obstacle].



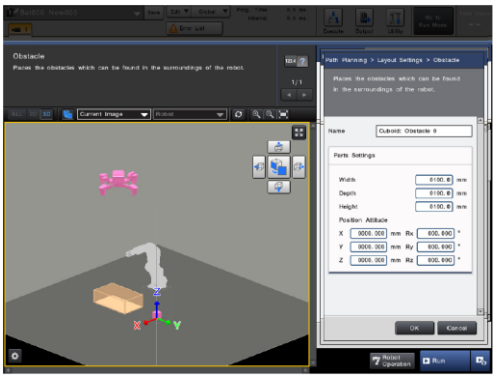
Left-click [Set Movement Limit Space], set each size with the center of the bottom of the movement limit space as the origin, and then left-click [OK].



To add an obstacle, left-click [+ Add].

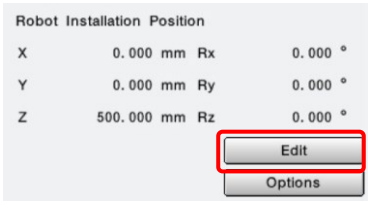


The [Parts Settings] screen appears, and an obstacle is added to the layout screen. Specify the name, size, and position attitude. After configuring the settings, left-click [OK].

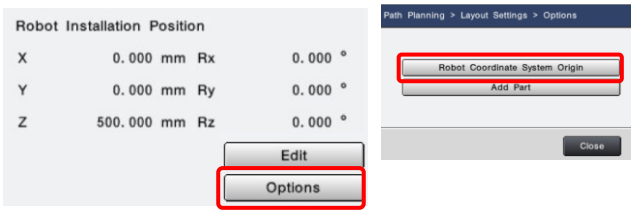


To set the robot's installation position and to set components such as cables and parts that are connected to the robot, left-click [Robot].

Left-click [Edit] to edit the robot's installation position.



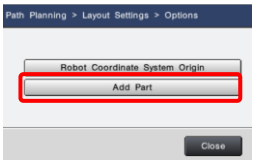
Left-click [Options] to display the [Options] screen. Left-click [Robot Coordinate System Origin] to edit the origin position of the robot coordinate system.



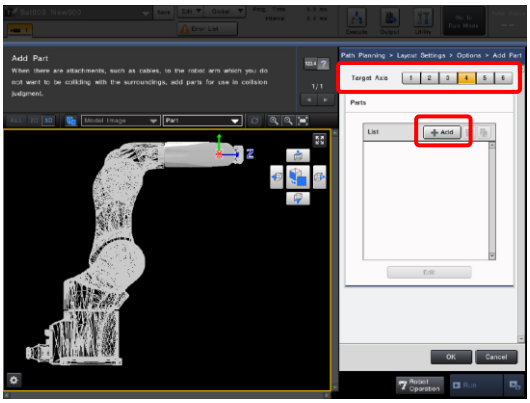
Left-clicking [Get From Robot] acquires the coordinate origin and displays the origin position on the robot on the screen. Left-click [OK] to return to the [Options] screen.

NOTICE	**Set [Robot Coordinate System Origin] to the same coordinates as on the robot side. If the coordinates differ, the robot may collide with the surrounding obstacles, leading to damage.**

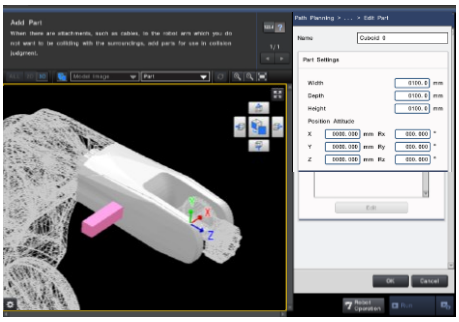
When cables, parts, and other such protrusions are connected to the robot, you can add their shapes to use them as targets for collision judgment. In this situation, left-click [Add Part] on the [Options] screen.



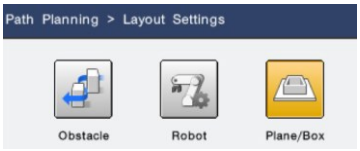
The [Add Part] screen appears. Select the [Target Axis], and then left-click [+ Add].



Set the [Name] and each size, and then left-click [OK].



To set the layout of the plane/box where the object is to be placed, left-click [Plane/Box].
You have to configure the settings with the 3D search function in advance. You can edit settings such as the position and thickness here.



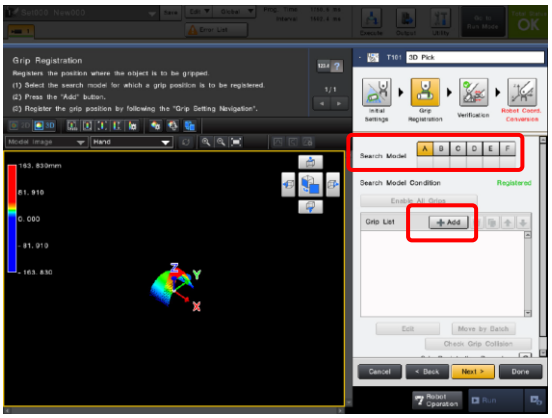
5-2 Grip Registration

Register the position the detected object will be picked up (gripped) at for each search model. You can register multiple grip positions for one search model.

Reference **The more grip positions that you register, the longer the processing time becomes. Register only the grip position that is a possible target in accordance with the state of the objects.**

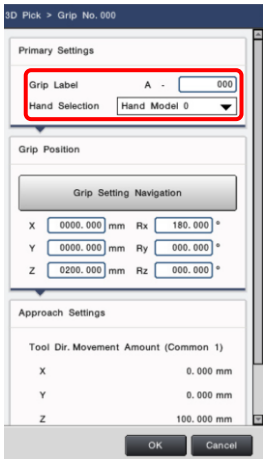
1. In the [Search Model] field, select the search model for which a grip position is to be registered.

Left-click [Add] next to [Grip List].



The [Grip No. ***] screen appears.

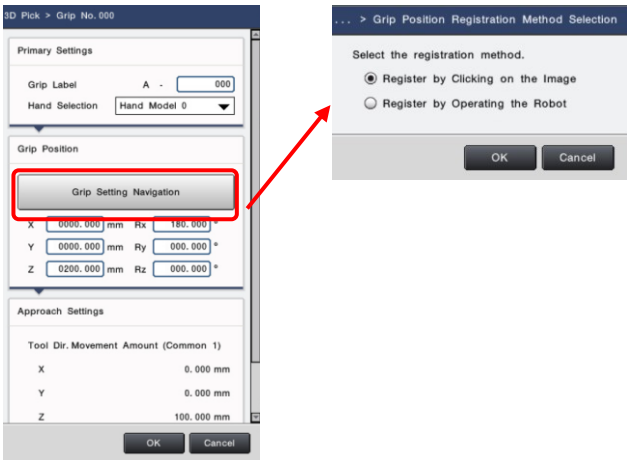
2. Specify the [Grip Label] and [Hand Selection] options.



Reference **The [Grip Label] indicates the priority order to use as detection results. For example, if a grip with priority 00 and a grip with priority 01 are registered, the grip with priority 01 will be output only when the grip with priority 00 cannot be found.**

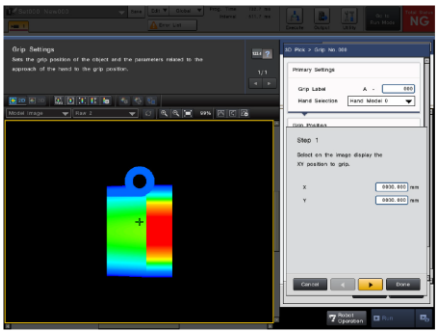
3. In the [Grip Position] field, left-click [Grip Setting Navigation].

The [Grip Position Registration Method Selection] screen appears.
Select the registration method, and then left-click [OK].

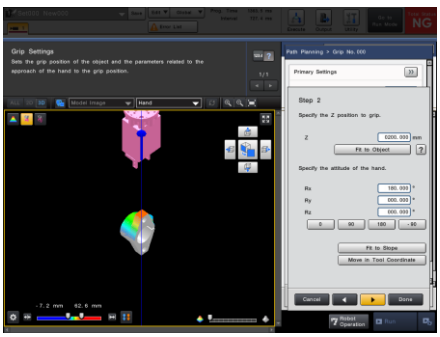


4. The grip position will be registered according to the registration method that you selected.

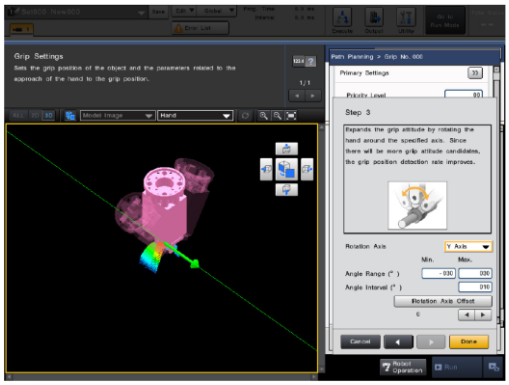
If you selected [Register by Clicking on the Image], left-click the grip position on the search model on the [Step 1] screen.
Left-click [▶].



Move the hand model to the grip position on the [Step 2] screen.
Specify the position at which to grip the object and the Z distance and Rz of the attitude.
Left-click [▶].

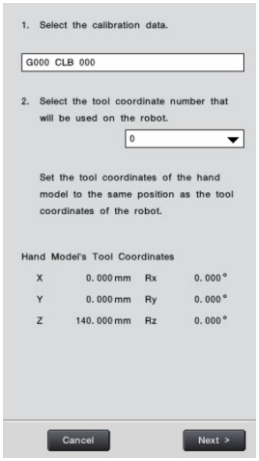


On the [Step 3] screen, specify the parameters to expand the grip attitude for the model.

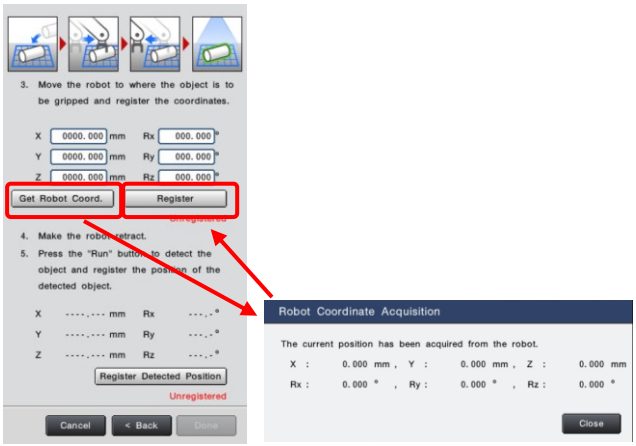


Adjust the [Rotation Axis] (the axis in which the hand is rotated), [Angle Range] (the range of angles through which to rotate the hand), [Angle Interval] (the interval between the angles through which to rotate the hand), and [Rotation Axis Offset] (the axis position offset).

If you selected [Register by Operating the Robot], select the calibration data and the tool coordinate number, and then left-click [Next].

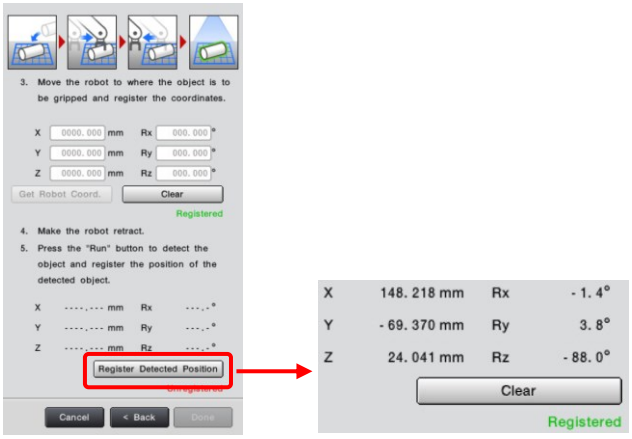


Move the robot hand to the position where the object that you placed is to be gripped. Left-click [Get Robot Coord.] to acquire the robot coordinates, and then left-click [Register] to register the coordinates.



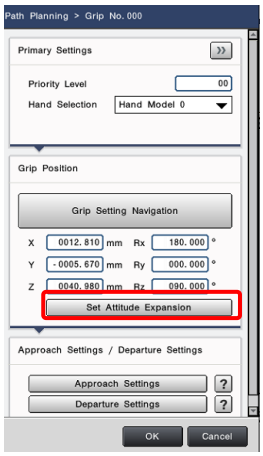
DANGER	**・ This operation sets the robot into motion. The operator needs to have completed specialized training.** **・ Make sure that the operation can be stopped immediately using the emergency stop switch in the event of a failure.**

Make the robot retract, and then click [Run] to detect the placed object with 3D Search. Check that the object is detected, and then left-click [Register Detected Position].



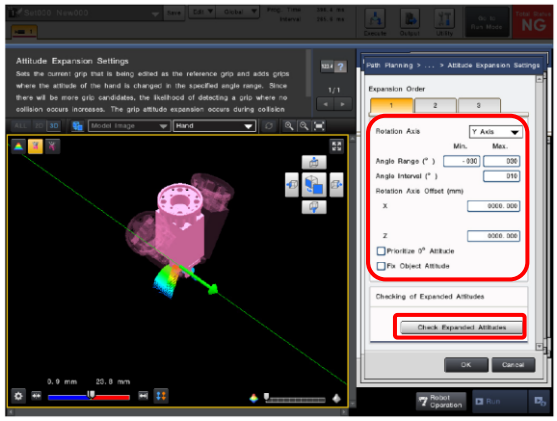
The object coordinates are registered and associated with the position attitude of the robot that will grip the object. Left-click [Done].

5. To expand the grip position according to the hand attitude, left-click [Set Attitude Expansion].



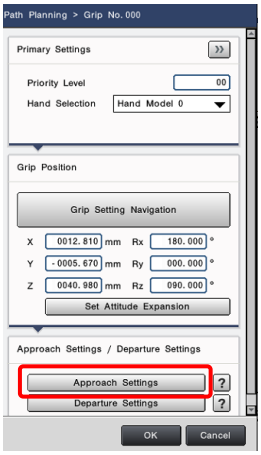
The [Attitude Expansion Settings] screen appears.
Set the following items on tabs 1, 2, and 3.
[Rotation Axis] (hand rotation axis)
[Angle Range] (rotation angle range)
[Angle Interval] (rotation angle interval)
[Rotation Axis Offset] (rotation axis position offset)
[Prioritize 0° Attitude] (prioritizes grips with no attitude changes)
[Fix Object Attitude] (when the object tilt is the same regardless of the grip attitude)

You can use [Check Expanded Attitudes] to check the resulting attitude.

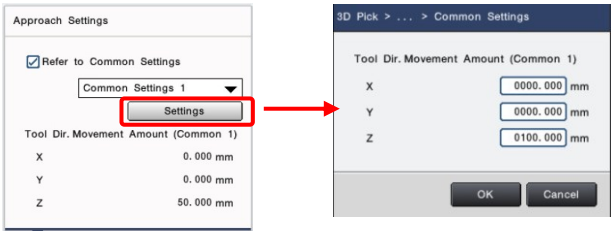


Left-click [OK] to return to the [Grip No. ***] screen.

6. Left-click [Approach Settings] in the [Approach Settings / Departure Settings] field.

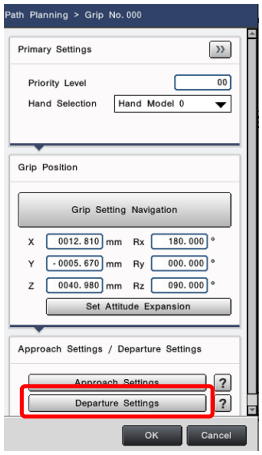


Set the approach position on the [Approach Settings] screen. Set the approach to the grip position being set with common settings or unique values.



Left-click [Move to Grip Position] in the [Approach Check] field. After confirming that the robot can approach the grip position, left-click [OK] to return to the [Grip No. ***] screen.

7. Left-click [Departure Settings] in the [Approach Settings / Departure Settings] field.



Set the [Departure Operation] and its corresponding [Movement Settings] on the [Departure Settings] screen.

[Lift]: Lifts the gripped object.
Use the movement settings to specify items such as the lifting direction and distance, the separation distance when lifting away from the box, and whether to pull sideways when objects overlap.

[Slide]: Slides the gripped object in the specified direction.
This operation is used when no valid grip that lifts the object is detected.
Use the movement settings to specify the pre-slide lift distance, the slide distance, and the slide direction.

NOTICE	**Since the object that is to be gripped is in contact with the surrounding objects, collision judgement with the surrounding objects is not performed during the departure operation. Make the departure distance as short as possible by specifying the minimum distance for the lift distance.** **When a grip for which [Slide] is specified is selected, the next target point after the depart destination and the end point of the path are replaced with the capture wait position without passing through the legs after the specified wait position. Note that the generated path is different.**

Once you have set the departure operation, left-click [OK] to return to the [Grip Registration] screen.

8. To register other grip positions, repeat the above registration procedure.

Once you have registered all the grip positions, left-click [Next] to proceed to [Path Settings].

5-3 Path Settings

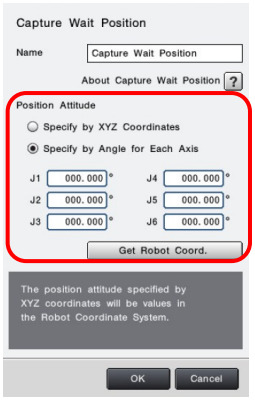
Create the path on which the robot will move from the start point (the capture wait position); through the approach position, grip position, and depart destination; and to the target position for the gripped object (the place position).

1. Select the [Capture Wait Position], and then left-click [Edit].

Point

Because the robot starts movement from the Capture Wait Position and returns to this position after placing the object at the place position, the Capture Wait Position must be set to a position that does not disrupt image capture.

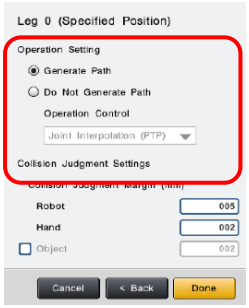
The [Capture Wait Position] screen appears.
Specify the position with Cartesian coordinates or with the angle of each axis. By left-clicking [Get Robot Coord.], you can obtain and register the position attitude at that point in time.



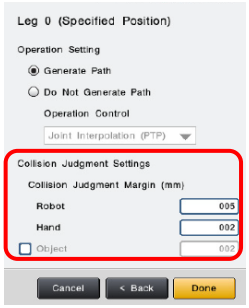
2. Select the [Above-box Position], and then left-click [Edit].

The [Leg ** (Specified Position)] screen appears.
In the same manner as the Capture Wait Position, specify the position with Cartesian coordinates or with the angle of each axis, and then left-click [Next].

Use [Operation Setting] to set the operation to the position.
Selecting [Generate Path] automatically generates waypoints that prevent the robot from colliding with obstacles. Selecting [Do Not Generate Path] outputs a path with joint interpolation (PTP) or linear interpolation (CP).



Use the [Collision Judgment Settings] to specify the collision judgment margins for the robot, hand, object, and obstacles.



3. Select the [Approach Position], and then left-click [Edit].

The [Leg ** (Approach Position)] screen appears.
Because this position is calculated automatically, it cannot be changed.
Edit the [Operation Setting] and [Collision Judgment Settings] in the same manner as for the [Above-box Position].

4. Select the [Grip Position], and then left-click [Edit].

The [Leg ** (Grip Position)] screen appears.
Because this position is calculated automatically, it cannot be changed.
Edit the [Collision Judgment Settings] in the same manner as for the [Above-box Position].
(Collision judgment is performed, and the waypoints are calculated automatically.)

5. Select the [Depart Destination], and then left-click [Edit].

The [Leg ** (Depart Destination)] screen appears.
Because this position is calculated automatically, it cannot be changed.
Edit the [Collision Judgment Settings] in the same manner as for the [Above-box Position].
(As explained earlier, collision judgment is not performed here.)

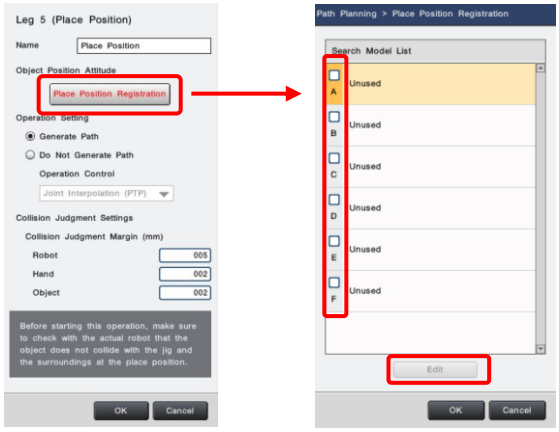
6. Select the [Above-box Position], and then left-click [Edit].

The [Leg ** (Specified Position)] screen appears.
Edit the [Position Attitude], [Operation Setting], and [Collision Judgment Settings] in the same manner as for the [Above-box Position] in step 2.

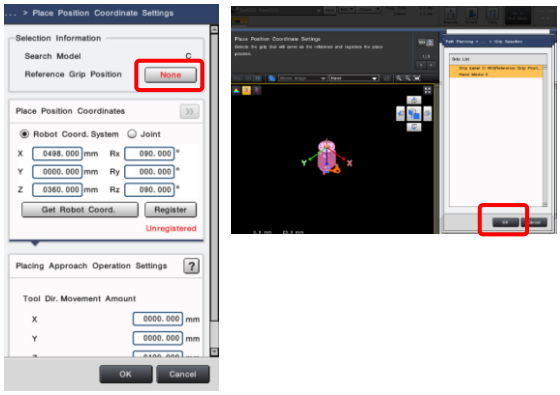
7. Select the [Place Position], and then left-click [Edit].

Point **For each search model, register the grip position that will be the reference and the coordinates at which to place the object. Registering these items makes it possible to output a place position that takes into account the grip attitude.**

The [Leg ** (Place Position)] screen appears.
Left-click [Place Position Registration].
The [Place Position Registration] screen appears.
Select the check box for the search model for which you want to register a place position, and then left-click [Edit].

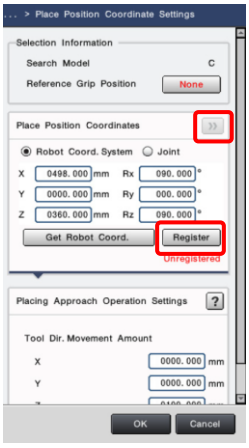


The [Place Position Coordinate Settings] screen appears.
Left-click [None] next to [Reference Grip Position] (which is the default status), select the grip position to use as the reference, and then left-click [OK].



Specify the place position coordinates, and then left-click [Register].

Left-click ⟩⟩ to display the [Register by Operating the Robot] screen on which you can register the actual robot position.



In the [Placing Approach Operation Settings] field, specify the position at which to approach the place position. Left-click [OK] to return to the [Place Position Registration] screen. To register a place position for another search model, repeat the above procedure.

8. Select the [0: Above-box Position], (next start position) and then left-click [Edit].

The [Leg ** (next start position)] screen appears.
Because this position is calculated automatically, it cannot be changed.

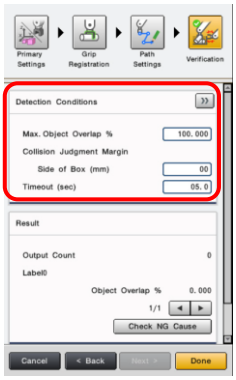
9. Add/insert new positions, delete unnecessary positions, change the order of positions, and perform similar operations as necessary.

5-4 Verification

Verify whether the robot can move along the set path while gripping an object and avoiding collisions with the box and obstacles.

1. Specify the detection conditions.

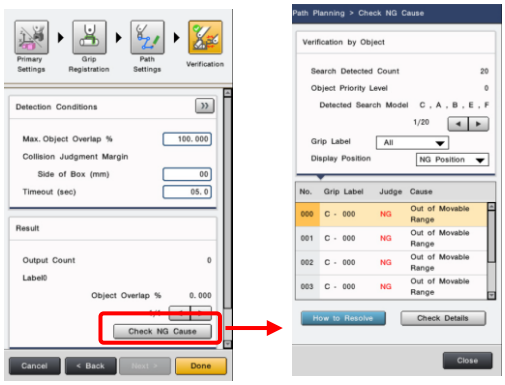
Specify the [Max. Object Overlap %] (a value that indicates how much of the top of this object is overlapped by another object; objects whose percentage of being overlapped is higher than this value are excluded from the candidates), [Side of Box] (the collision judgment margin from the side of the box), and [Timeout] (the upper limit of the processing time) options.



Reference **Left-click [»] to configure more advanced settings. For details, see the "CV-X Series User's Manual (3D Vision-Guided Robotics Edition)."**

2. In the [Result] field, check that the number of possible grips is the expected result.

If you want to check the cause of an NG result, left-click [Check NG Cause]. Select the [Detected Search Model], [Grip Label], and [Display Position] to check the applicable candidates. You can also use [Check Details] to check separate detailed information and [How to Resolve] to check typical countermeasures.



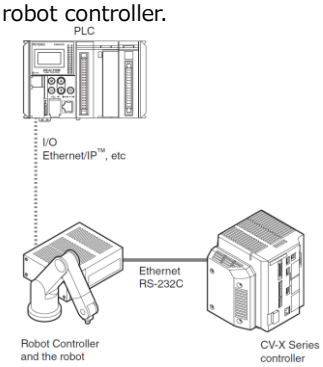
Reference **For details on each item, see the "CV-X Series User's Manual (3D Vision-Guided Robotics Edition)."**

Chapter 6 Operation Preparation

Configure robot output settings according to the system configuration during the operation phase. This chapter also introduces the robot-side sample program.

6-1 System Configuration During the Operation Phase

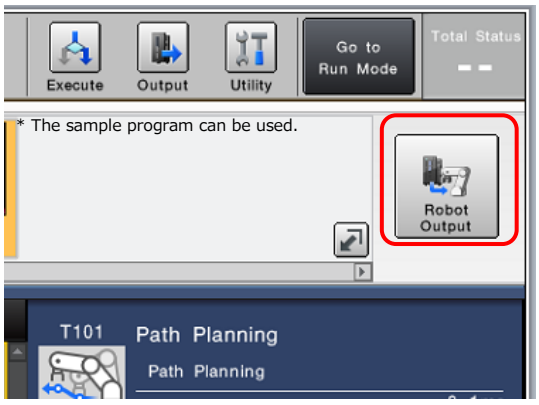
The system can be operated with the same configuration (robot controller + CV-X) as during the setting phase. If there is a PLC, perform control by connecting only to the robot controller.



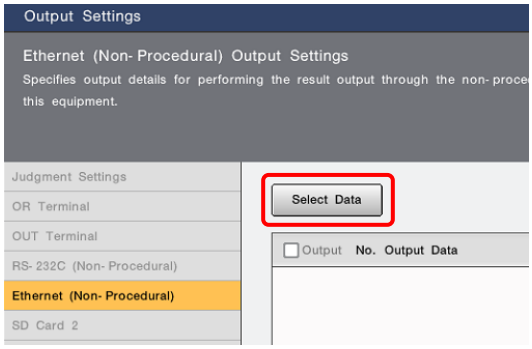
6-2 Robot Output

Reference · **When creating new settings, the default output details are assigned.**

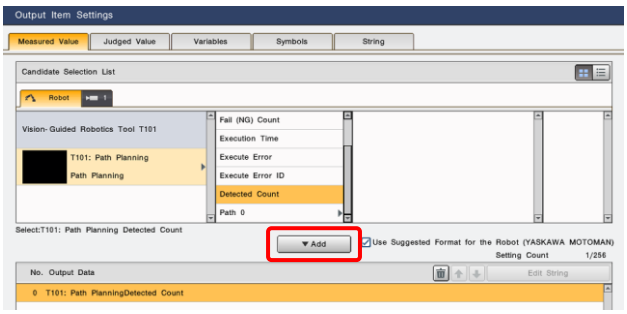
1. Click [Robot Output].



2. Click [Select Data].

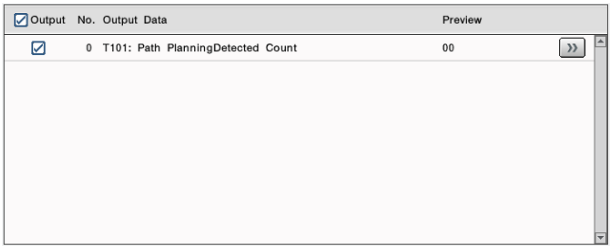


3. Select the data to output, and then click [Add].



Example of settings when using the sample program creation function

- Outputting the measured values
  Measured Value > Robot > Tool [T101: Path Planning] > Detected Count



4. Click [OK] to return to the main screen.

Point **The [Data Delimiter] and the necessary output data differ depending on the manufacturer of the connected robot. Follow the messages displayed at the bottom of the screen.**

5. Click [Go to Run Mode] to switch to run mode.

6. Click [Run].

7. Display [Utilities] > [Ethernet Monitor] or [RS-232C Monitor], and then check the output data that has actually been sent.

Point **To perform automatic robot operation, a program that performs CV-X measurements from the robot side before operating the robot on the basis of the output data is required.**

6-3 Robot Programs During the Operation Phase

During actual operation, it is necessary to add instructions, such as those for operations to open and close the hand, to the robot program to match the actual application.

Reference **You can download the operation program from the "3D Vision-Guided Robotics System User Support Site" on the KEYENCE website. For the usage method, see the 🕮 "Vision-Guided Robotics System Robot Connection Manual."**

Revision History

Date	Revision number	Revision contents
April 2020	Official release	
July 2020	2nd edition	Edition for version 5.3.0000

Specifications are subject to change without notice.

KEYENCE CORPORATION

1-3-14, Higashi-Nakajima, Higashi-Yodogawa-ku, Osaka, 533-8555, Japan PHONE: +81-6-6379-2211

www.keyence.com/glb

AUSTRIA
Phone: +43 2236 378266 0

BELGIUM
Phone: +32 15 281 222

BRAZIL
Phone: +55-11-3045-4011

CANADA
Phone: +1-905-366-7655

CHINA
Phone: +86-21-3357-1001

CZECH REPUBLIC
Phone: +420 220 184 700

FRANCE
Phone: +33-1-56-37-78-00

GERMANY
Phone: +49-6102-3689-0

HONG KONG
Phone: +852-3104-1010

HUNGARY
Phone: +36 1 802 7360

INDIA
Phone: +91-44-4963-0900

INDONESIA
Phone: +62-21-2966-0120

ITALY
Phone: +39-02-6688220

KOREA
Phone: +82-31-789-4300

MALAYSIA
Phone: +60-3-7883-2211

MEXICO
Phone: +52-55-8850-0100

NETHERLANDS
Phone: +31 40 20 66 100

PHILIPPINES
Phone: +63-2-8981-5000

POLAND
Phone: +48 71 36861 60

ROMANIA
Phone: +40 269 232 808

SINGAPORE
Phone: +65-6392-1011

SLOVAKIA
Phone: +421 2 5939 6461

SLOVENIA
Phone: +386 1 4701 666

SWITZERLAND
Phone: +41 43 455 77 30

TAIWAN
Phone: +886-2-2721-8080

THAILAND
Phone: +66-2-369-2777

UK & IRELAND
Phone: +44 1908-696-900

USA
Phone: +1-201-930-0100

VIETNAM
Phone: +84-24-3772-5555

A4WW1-MAN-2010

 124457GB 2070-2 972GB