FANUC Robot series

R-30*i*B Plus/R-30*i*B Mate Plus/R-30*i*B Compact Plus/
R-30*i*B Mini Plus CONTROLLER

*i*RVision 2D Camera Application

OPERATOR'S MANUAL

B-83914EN-2/03

• Original Instructions

Thank you very much for purchasing FANUC Robot.

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

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.
Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume. It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

SAFETY PRECAUTIONS

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

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell.
For safe use of FANUC robots, you must read and follow the instructions in "FANUC Robot series SAFETY HANDBOOK (**B-80687EN)**".

1 PERSONNEL

Personnel can be classified as follows.

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

Programmer or Teaching operator:
- Operates the robot
- Teaches the robot inside the safeguarded space

Maintenance technician:
- Operates the robot
- Teaches the robot inside the safeguarded space
- Performs maintenance (repair, adjustment, replacement)

- The operator is not allowed to work in the safeguarded space.
- The programmer or teaching operator and maintenance technician are allowed to work in the safeguarded space. Works carried out in the safeguarded space include transportation, installation, teaching, adjustment, and maintenance.
- To work inside the safeguarded space, the person must be trained on proper robot operation.

Table 1 (a) lists the work outside the safeguarded space. In this table, the symbol “O” means the work allowed to be carried out by the specified personnel.

Table 1 (a) List of work outside the Safeguarded Space

	Operator	Programmer or Teaching operator	Maintenance technician
Turn power ON/OFF to Robot controller	O	O	O
Select operating mode (AUTO/T1/T2)		O	O
Select remote/local mode		O	O
Select robot program with teach pendant		O	O
Select robot program with external device		O	O
Start robot program with operator’s panel	O	O	O
Start robot program with teach pendant		O	O
Reset alarm with operator’s panel		O	O
Reset alarm with teach pendant		O	O
Set data on teach pendant		O	O
Teaching with teach pendant		O	O
Emergency stop with operator’s panel	O	O	O
Emergency stop with teach pendant	O	O	O
Operator’s panel maintenance			O
Teach pendant maintenance			O

During robot operation, programming and maintenance, the operator, programmer, teaching operator and maintenance technician take care of their safety using at least the following safety protectors.

- Use clothes, uniform, overall adequate for the work
- Safety shoes
- Helmet

2 DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with "**WARNING**" or "**CAUTION**" according to its severity. Supplementary information is indicated by "**NOTE**". Read the contents of each **"WARNING**", "**CAUTION**" and "**NOTE**" before using the robot.

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

TABLE OF CONTENTS

Know-How

Introduction

1 PREFACE

This chapter describes an overview of this manual which should be noted before operating the *i*RVision function.

1.1 OVERVIEW OF THE MANUAL

This manual describes how to operate *i*RVision controlled by the R-30*i*B Plus/R-30*i*B Mate Plus/R-30*i*B Compact Plus/R-30*i*B Mini Plus controller. This manual is directed to users who are reasonably familiar with the FANUC two-dimensional vision.
In this manual, only the operation and the technique of programming for the dedicated sensor functions are explained, assuming that the installation and the setup of the robot are completed. Refer to the "OPERATOR'S MANUAL (Basic Function) B-83284EN" about other operations of FANUC Robots.

> ⚠ **CAUTION**
> This manual is based on R-30*i*B Plus/R-30*i*B Mate Plus/R-30*i*B Compact Plus/R-30*i*B Mini Plus system software version 7DF5/06. Note that the functions and settings not described in this manual may be available, and some notation differences are present, depending on the software version.

Volume	Chapter	Chapter Title	Description
Introduction	Chapter 1	Introduction	Gives an overview of and a guide to using this manual and related manuals.
	Chapter 2	About Vision System	Gives an overview of the functions of *i*RVision and the basic knowledge required to use the functions.
	Chapter 3	Features	Gives an overview of the four types of Vision Processes.
Setup	Chapter 1	2-D Single-View Vision Process	Explains the 2-D Single-View Vision Process start-up procedures.
	Chapter 2	2-D Multi-View Vision Process	Explains the 2-D Multi-View Vision Process start-up procedures.
	Chapter 3	Depalletizing Vision Process	Explains the Depalletizing Vision Process start-up procedures.
	Chapter 4	3-D Tri-View Vision Process	Explains the 3-D Tri-View Vision Process start-up procedures.
Know-how	Chapter 1	Frame Setting	Explains the methods for frame setting with a pointer tool and frame setting with the Automatic Grid Frame Setting function.
	Chapter 2	Camera Data Setting	Explains the method for camera data setting.
	Chapter 3	Setup of Snap in Motion	Explains the method for snapping without stopping the motion of the robot.
	Chapter 4	FAQs for Troubleshooting	Explains the causes and actions to take regarding a variety of problems.

Indications in this Manual

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

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

Explanation of teach pendant operation

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

Simple Mode and Advanced Mode

*i*RVision has the simple mode, which hides less frequently-used setting items, and the advanced mode, which shows all setting items. Unless otherwise specified, screens and operations mentioned in this manual are for the simple mode. For details on the simple mode and the advanced mode, refer to the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

1.2 RELATED MANUALS

This section introduces related manual.

Manual	Spec. No.	Description
OPERATOR'S MANUAL (Basic Function)	B-83284EN	Main manuals of the Controller • Setting the system for manipulating workpieces • Operating the robot • Creating and changing a program • Executing a program • Status indications • Backup and restore robot programs. These manuals are used on a robot applicable design, robot installation, and robot teaching.
MAINTENANCE MANUAL	B-83195EN	Maintenance and connection of R-30*i*B/R-30*i*B Plus Controller
MAINTENANCE MANUAL	B-83525EN	Maintenance and connection of R-30*i*B Mate/R-30*i*B Mate Plus Controller
MAINTENANCE MANUAL	B-83555EN	Maintenance and connection of R-30*i*B Mate/R-30*i*B Mate Plus Controller (Open Air)
OPERATOR'S MANUAL (Alarm Code List)	B-83284EN-1	Alarm code list for the Controller. Causes of alarm occurrence and measures to be taken.
Optional Function OPERATOR'S MANUAL	B-83284EN-2	Software optional functions of robot controllers.
Sensor Mechanical Unit / Control Unit OPERATOR'S MANUAL	B-83984EN	Method for connection between Controller and sensors such as a camera or 3D Laser Vision Sensor used for *i*RVision, and the maintenance method of sensors.
*i*RVision OPERATOR'S MANUAL (Reference)	B-83914EN	Reference manual for various functions of *i*RVision • Each functions which are provided by *i*RVision • Meanings (e.g. the items on *i*RVision setup screen, the arguments of the instruction, and so on
*i*RVision 3D Laser Vision Sensor Application OPERATOR'S MANUAL	B-83914EN-4	Manual to refer to first when starting up a robot system that performs a 3D offset by the 3D Laser Vision Sensor using *i*RVision. • System startup procedures, program creation method, caution, technical know-how, responses to various cases, etc. when performing a 3D offset by the 3D Laser Vision Sensor using *i*RVision.
*i*RVision Inspection Application OPERATOR'S MANUAL	B-83914EN-5	Manual to refer to first when starting up a robot system that performs non-defective/defective inspection of workpieces using *i*RVision. • System startup procedures, program creation methods, caution, technical know-how, responses to various cases, etc. when performing non-defective/defective inspection of workpieces using *i*RVision.

Manual	Spec. No.	Description
*i*RVision Bin Picking Application OPERATOR’S MANUAL	B-83914EN-6	Manual to refer to first when starting up a robot system that performs bin picking using *i*RVision. • System startup procedures, program creation methods, caution, technical know-how, responses to various cases, etc. when performing bin picking using *i*RVision.
*i*RPickTool OPERATOR'S MANUAL	B-83924EN	Manual to refer to first when starting up a robot system that performs visual tracking using *i*RVision. • System startup procedures, program creation methods, caution, technical know-how, responses to various cases, etc. when performing visual tracking using *i*RVision.
Ethernet Function OPERATOR’S MANUAL	B-82974EN	Robot controller networking options such as FTP, RIPE, PC Share, and so on.

2 ABOUT VISION SYSTEM

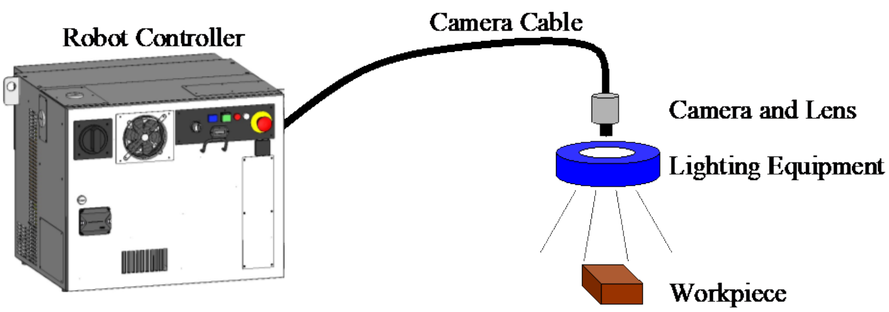
This chapter explains the fundamental items of the vision system.
The following eight items are explained.

1 Basic configuration
2 Fixed camera and robot-mounted camera
3 Size of a camera's field of view
4 Fixed frame offset and tool offset
5 Calculation of the offset data
6 Part Z height
7 Memory card preparation
8 Calibration Grid

2.1 BASIC CONFIGURATION

*i*RVision consists of the following components:

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



Basic configuration of *i*RVision

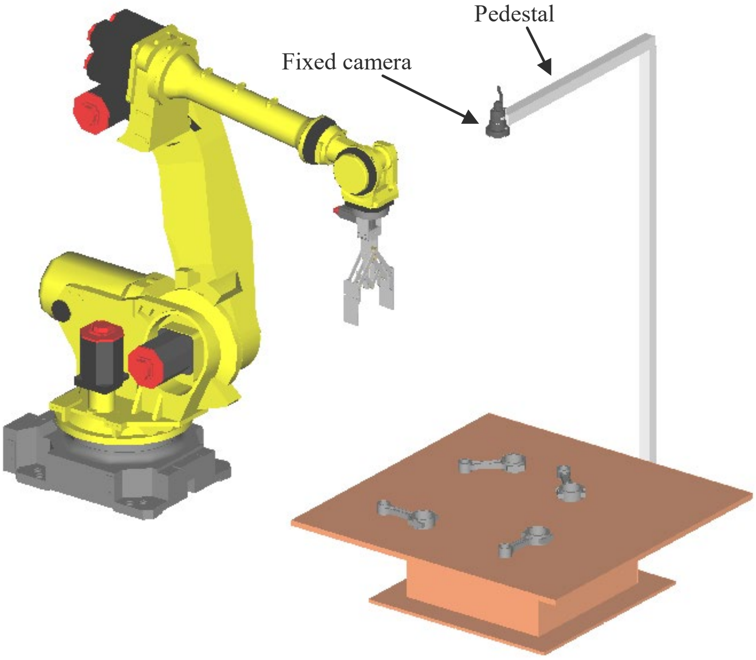
For detailed information about the connection method between the Robot Controller and a camera, please refer to "Sensor Mechanical Unit/ Control Unit OPERATOR'S MANUAL B-83984EN".
The camera and lens of 3D Laser Vision Sensor are sane as the two-dimensional camera, so the 3D Laser Vision Sensor can also be used for the two-dimensional applications.

2.2 FIXED CAMERA AND ROBOT-MOUNTED CAMERA

Decide where to place the camera according to the workpieces size and location.

Fixed camera

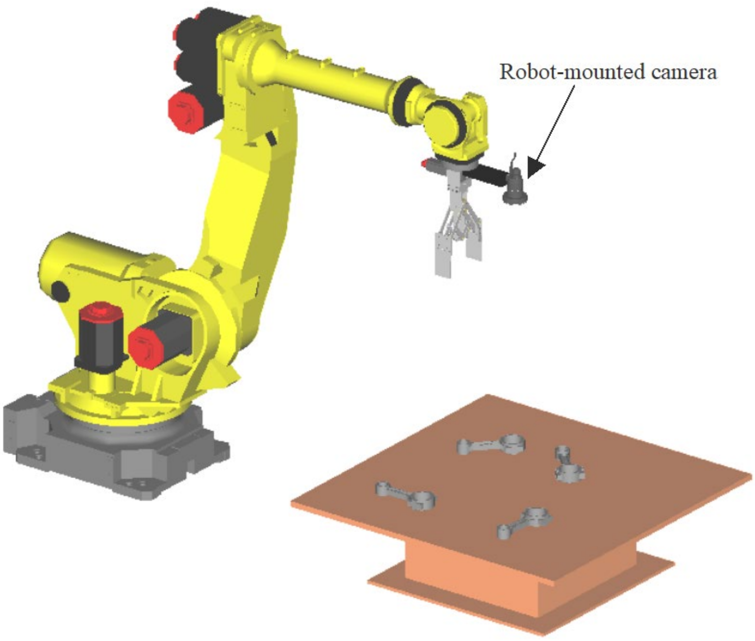
- Detect workpieces using the camera installed on the stand.
- A fixed camera will always snap the same place from the same distance.
- While the robot transfers the workpieces, *i*RVision can detect the other workpieces, so the cycle time can be shortened.
- Use a sufficient strength camera stand so that the camera doesn't vibrate.



Fixed camera

Robot-mounted camera

- The robot-mounted camera is mounted on the wrist unit of the robot.
- By moving the robot, you can measure different places with a robot-mounted camera.
- When a robot-mounted camera is used, *i*RVision calculates the position of the workpiece based on the movement of the robot.
- The camera must be mounted on the final axis of the robot. For example, when a six axis robot is used, the camera must be mounted on the sixth axis of the robot.
- The camera cable moves according to the robot movement, so be careful so that the cables doesn't tangle.



Robot-mounted camera

2.3 SIZE OF A CAMERA'S FIELD OF VIEW

Depending on the size and location of the workpiece, determine the size of the field of view of the camera.

The size of the field of view of the camera is determined by three factors: The size of the image sensor, the focal distance of the lens, and the distance from the camera to the workpiece.

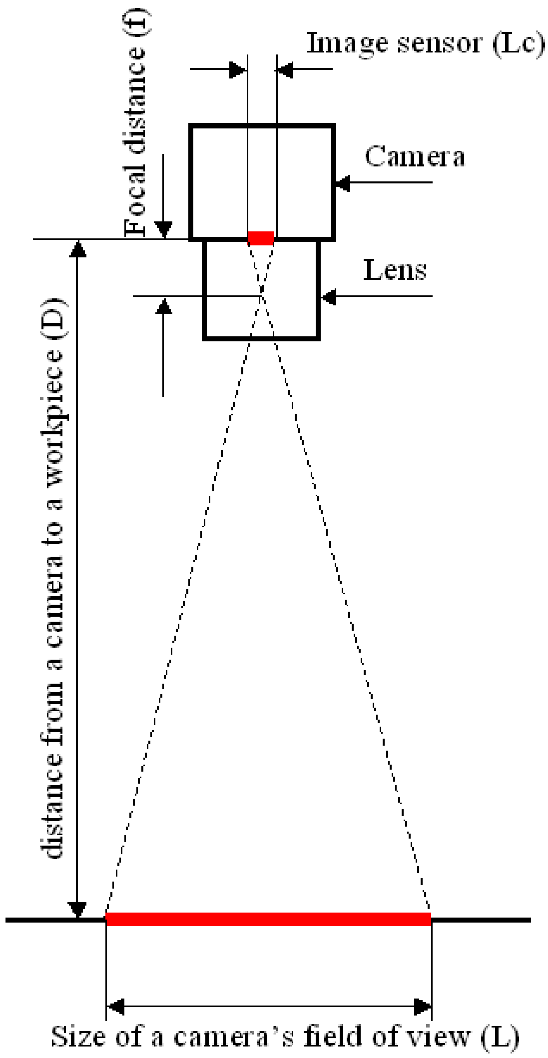
The size of the image sensor (Lc) is calculated by the following formula.
Lc = Cell size = Image size (pixels)

The rough value of the field of view of the camera (L) is calculated by the following formula.
$L = (D - f) \div f \times Lc$

When the distance D from a camera to a workpiece is 700mm and the monochrome camera (SC130EF2) is used, the view size is shown below table.

Focal distance of the lens	Size of the field of view
8 mm	587 mm × 469 mm
12 mm	389 mm × 311 mm
16 mm	290 mm × 232 mm
25 mm	183 mm × 147 mm

The calculation result is an approximate value. Some difference may occur between the calculated value and the actual measurement value. When an accurate value is required, please confirm by the actual measurement.



Size of a field of view of a camera

If you want to enlarge the view size, there are the following methods.

- Increase the distance from the camera to the workpiece.
- Exchange to a lens with the shorter focal distance.

If the distance from a camera to a workpiece is too near, a lens is not in focus.
The minimum object distance of each lens offered from FANUC is shown in the following table.
The distance from the tip of the workpiece should be longer than the minimum object distance.

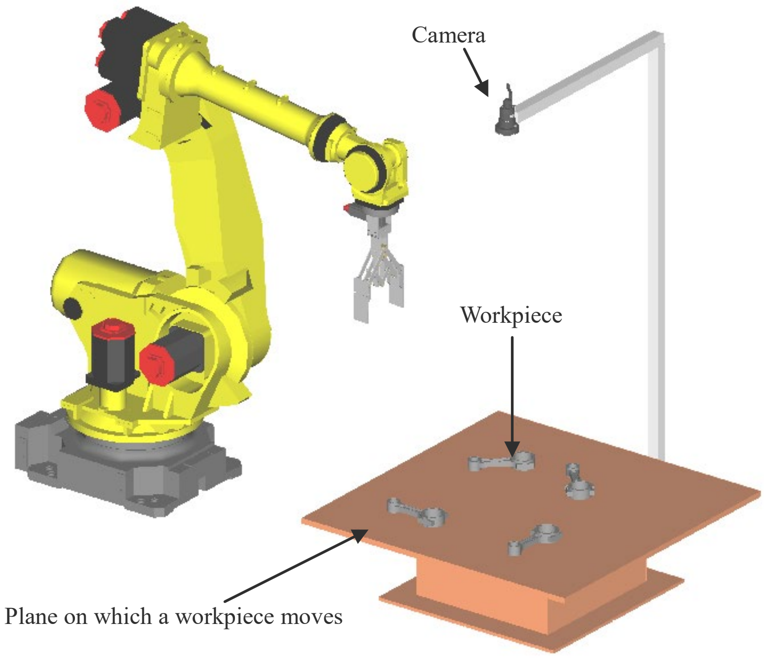
Focal distance of the lens	Minimum object distance
8 mm	260 mm
12 mm	260 mm
16 mm	290 mm
25 mm	210 mm

2.4 FIXED FRAME OFFSET AND TOOL OFFSET

The fixed frame offset and the tool offset can be used to offset the robot positions. *i*RVision supports both kinds of robot position offsets.

Fixed frame offset

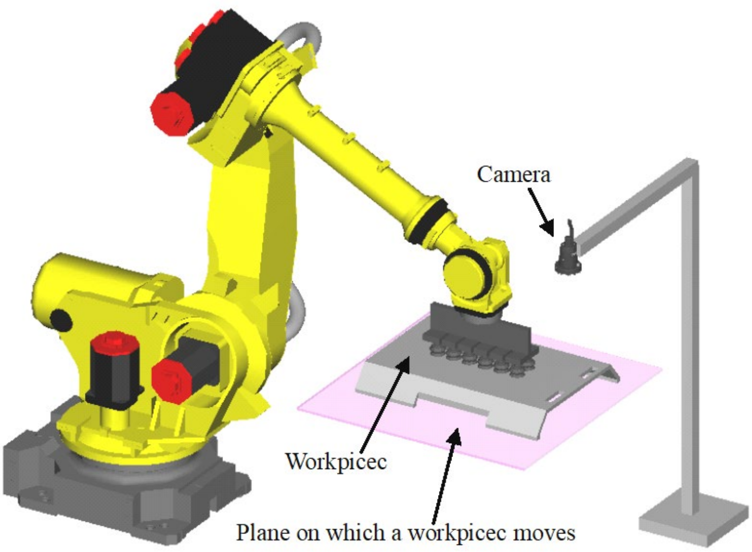
Detect the workpiece on the table, and offset the robot positions so that the robot works (for example, the robot picks up the workpiece.) in correct.



Fixed frame offset

Tool offset

Detect the workpiece which gripped by the robot, and offset the robot positions so that the robot works (for example, the robot places up the workpiece.) in correct.



Tool Offset

2.5 CALCULATION OF THE OFFSET DATA

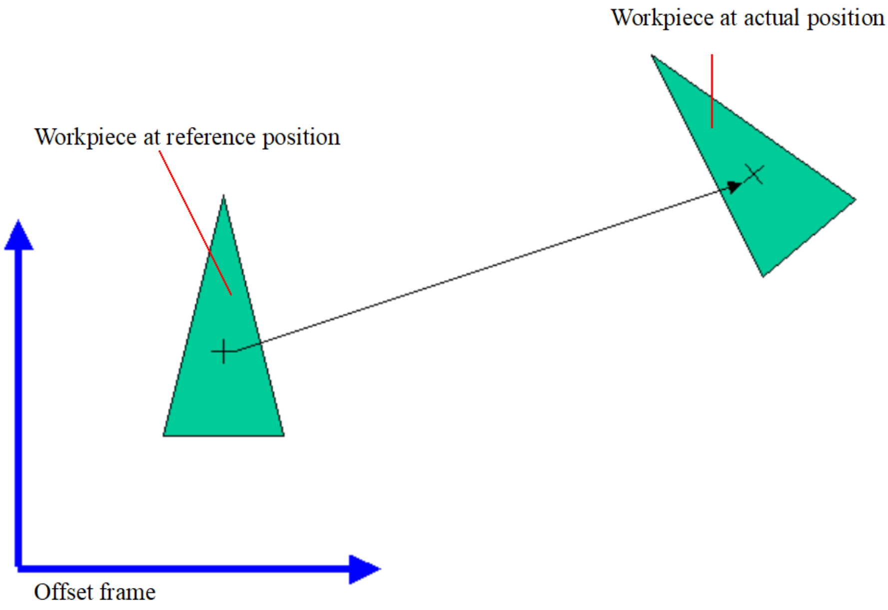
In this subsection, the calculation method of the offset data is explained.

Reference position and actual position

The offset data is calculated from the position of the workpiece of when teaching the robot program and the position of the current workpiece. The position of the workpiece of when the robot program was taught is called as the reference position, and the current position of workpiece is called the actual position. *i*RVision measures the reference position when the robot program is taught, and stores it internally. The operation of teaching the reference position to *i*RVision is called reference position setting.

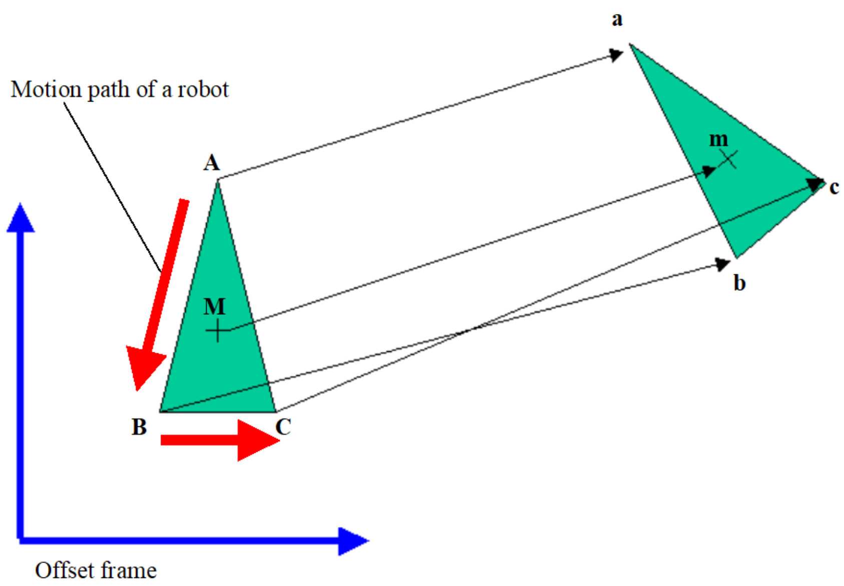
Offset data

In the case of the following figure, the position of "+" mark is a found position of a workpiece. If a robot approaches only to the position of "+" mark, the offset data can be calculated by subtracting the value of the actual position and the reference position. When the calculation of the offset data is subtraction, it is easy to understand, however there are also limitations.



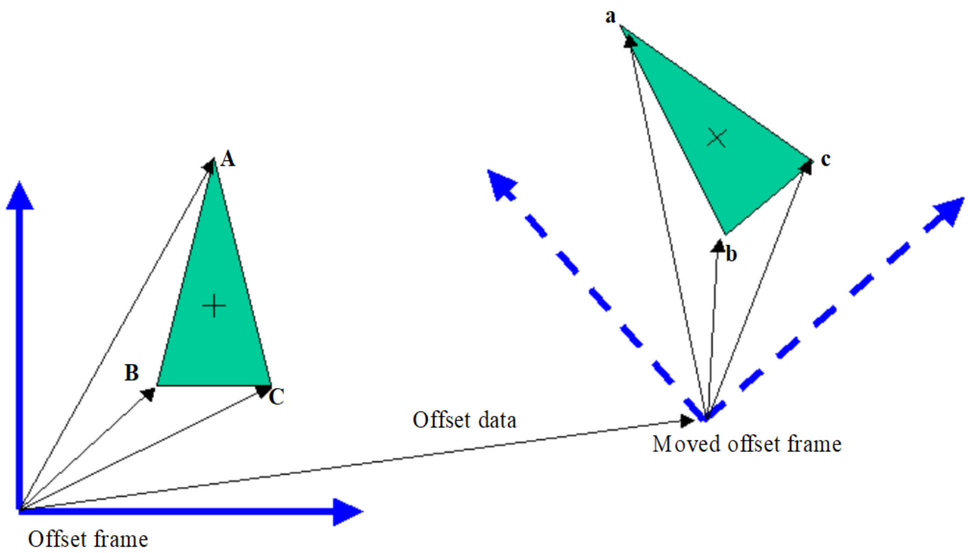
Offset calculation by subtraction

In the following figure, the position M is the reference position and the position m is the actual position. A workpiece is placed on the reference position and the robot traces from the position A to the position B and C. When the workpiece is placed at the actual position, to trace the -- a, b and c --, each positions information are required. However, the movement of (a – A), (b – B) and (c – C) differ from the movement of the found position (m – M). So, it is necessary to calculate the offset data of a, b and c individually.



Position Information and movement amount

*i*RVision uses an offset frame, it is unnecessary to calculate the each position individually. In the following figure, *i*RVision moves the offset frame to a new position. The position of the workpiece relative to the offset frame is the same as the position of the workpiece at the reference position by moving the offset frame, it becomes unnecessary to calculate the offset data for each point individually, and teaching becomes easy. *i*RVision outputs the movement of offset frame as the offset data. Since the offset data is the movement of the user frame, it is not the physically movement of the workpiece. Moreover, the offset data does not become an intuitive value in many cases. Normally, when the amount of rotation of the workpiece is the larger or the distance from the origin of the user frame to the workpiece is the further, the value of the offset data differs from the physically movement of the workpiece.



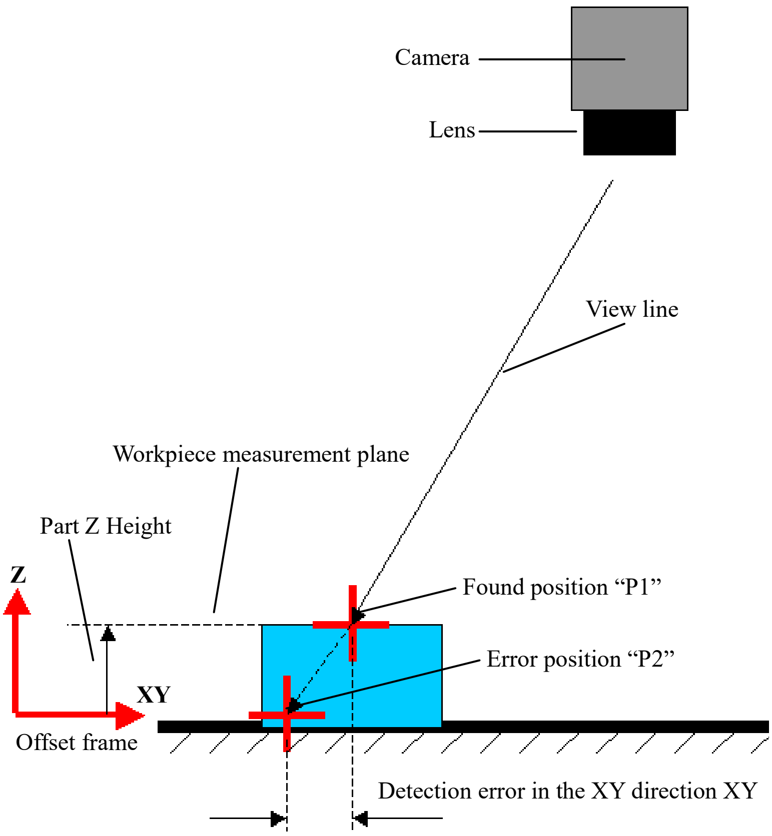
Offset calculation by shifting a frame

2.6 PART Z HEIGHT

In the following figure, the two-dimensional camera detects a workpiece. In this case, the found position of the workpiece will be in somewhere on the view line which connects from the workpiece to the camera.

In order to determine the point on the view line, it is necessary to define the height of a workpiece (Part Z Height) beforehand. In two-dimensional offset with *i*RVision, the height of the workpiece measurement plane on the offset frame is used as the part z height. By setting up the part z height, the XY position of the workpiece is correctly calculated. ("P1" in the following figure)

The part Z height is the important setting and which influences to the offset accuracy of the robot. So, please set up the part Z height correctly. When the workpiece is in the center of field of view, the offset error is too small, but when the workpiece moves to the edges of the field of view, the offset error becomes large. In this case, it is possible that part Z height is not set properly. In the following figure, when 0 mm is incorrectly set up in the part z height, the found position of the workpiece is calculated as it is "P2", and an offset error occurs in the XY direction.



Part Z Height

2.7 MEMORY CARD PREPARATION

*i*RVision can save undetected images to a memory card or a USB memory inserted into the robot controller. It is recommended that at the time of system start-up and integration, a memory card or a USB memory be inserted to save undetected images to the memory card or a USB memory. By doing so, the locator tool parameter can be adjusted using undetected images. Moreover, when the system is reinstalled after being moved, for example, camera images before reinstallation, if saved, can be checked against camera images after reinstallation to see if there is any major difference.
To enable vision log, check “Enable logging” on the *i*RVision configuration screen. For details, refer to the description of Vision Configin the "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN".
Note that even if "Log Failed Images" is set in the vision program, no un-detected images can be saved when no memory card or no USB memory is inserted.
When the free space of the memory device is less than the specified value (1 MB by default), old vision logs are deleted to make enough free space for writing a new vision log. Even if the free space of the memory card/USB memory is less than the specified value, files other than vision logs of the vision system are not deleted. If there are no vision logs which can be deleted, the ‘CVIS-130 No free disk space to log’ alarm is posted and the vision log will not be recorded.

⚠ **CAUTION**

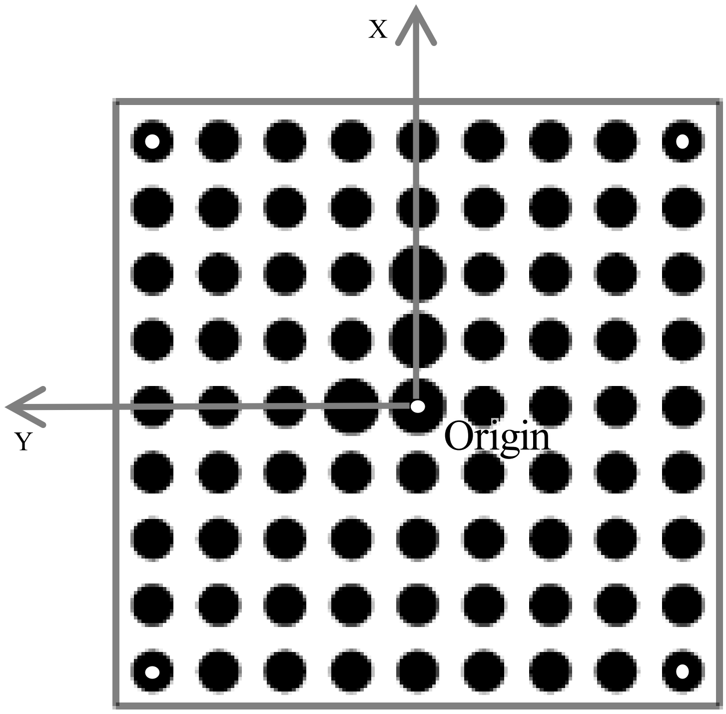
1 As it takes a long time to delete the execution history, we recommend that you regularly transfer the data for the execution history to your PC and ensure you have sufficient free space in your memory card or USB memory. For details on how to export the execution history to an external device or to delete it, refer to the description of Vision Log menu in the "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN".
2 On a memory card or USB memory, data other than execution history for *i*RVision may be recorded. If the free space drops below the designated capacity, the next time a vision Process is executed, history will be deleted until the remaining capacity reaches the designated capacity. Depending on the amount of data that is deleted, it may take a while to get into a state in which execution of the next Vision Process can start. For example, saving a backup to a memory card or USB memory corresponds to this case.
3 Do not insert a memory card in which execution history has been recorded using another robot controller. If you carry out line execution or test execution of a vision process with the memory card still inserted, the execution history that was recorded using the original robot controller may be overwritten.
4 Format devices such as memory card or USB memory to FAT16.
5 If you record images, it may take time to execute detection. Basically, set things up so that images will not be recorded after you have finished adjustment of the vision system. For details, refer to the description of Vision Log in the "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN".

A memory card or a USB memory, when inserted, can be used to back up all data in the robot controller. If all data in the robot controller is backed up, the vision data can be backed up at the same time. Be sure to back up all data in the robot controller upon completion of startup or integration.

Moreover, use a memory card or a USB memory recommended by FANUC. If a memory card or a USB memory other than those recommended is used, a normal operation is not guaranteed, and a bad influence may occur on the controller.

2.8 CALIBRATION GRID

A calibration grid is a multi-purpose jig that is used for a variety of purposes, such as grid pattern calibration and grid frame setting.
In *i*RVision, a calibration of a camera is performed using a calibration grid with a default pattern drawn. When the camera snaps an image of the grid as shown below, *i*RVision automatically recognizes the positional relationship of the calibration grid and the camera, lens distortion, the focal distance, etc.



Example of a frame using a calibration grid

All the black dots of the calibration grid are arrayed in a square lattice. There are four large black dots near the center that indicate the frame origin and direction as shown in the picture. The ratio of the diameter of a large black dot to that of other black dots is approximately 10:6.

For the five grid points arranged in the center and at the four corners, there is a white dot with a diameter of 1 mm placed at the center of the black dot. This white dot is used when setting the frame with touch-up using the robot's TCP.

Depending on the application, a calibration grid can be used by fixing it to a table or attaching it to the robot's gripper. In either case, it is necessary to set the arrangement position and direction (mounting information) of the calibration grid when performing calibration for the camera.

To set up the information for mounting the calibration grid, attach a pointer tool to the robot's gripper and set it up by physically performing touch-up (calibration grid setting using touch-up), or set it up automatically without any contact by using a camera and measuring a grid pattern (grid frame setting).

3 FEATURES

The following four application methods are explained below.

- 2D Single-view Vision Process
- 2D Multi-view Vision Process
- Depalletizing Vision Process
- 3D Tri-View Vision Process

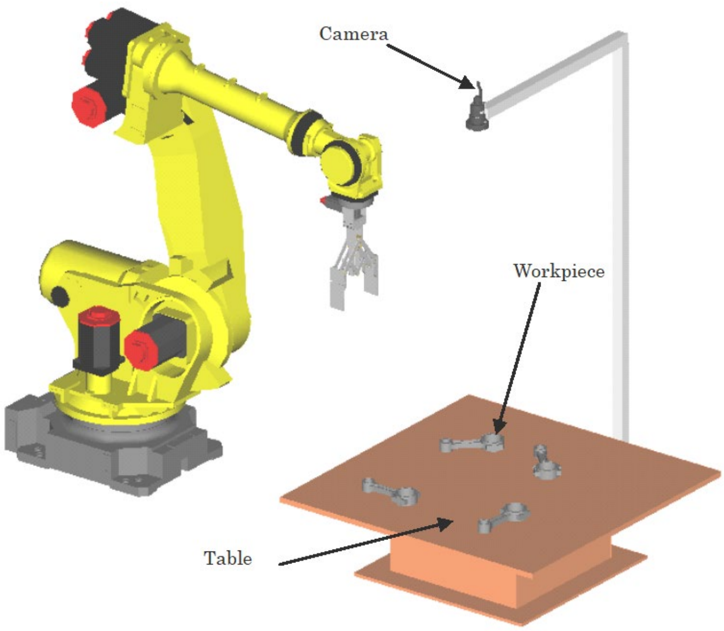
The 2D Single-view Vision Process and 2D Multi-view Vision Process can detect the parallel movement of the workpiece, (X, Y) direction or the rotational movement (R) direction, and offset the robot position. The Depalletizing Vision Process can detect not only the parallel movement (X, Y, R) but also the height (Z) of the workpieces. The 3D Tri-View Vision Process can detect the (X, Y, Z, W, P, R) of the workpiece.

This chapter explains the outlines of the above four applications, and Chapters 1 to 4 explain the setup procedures in detail. The 2D Single-view Vision Process is the most standard vision application. The setup procedure of the 2D Single-view Vision Process can apply to other vision application settings.

For details of each setting item, refer to the "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN".

3.1 OVERVIEW OF 2D SINGLE VIEW VISION PROCESS

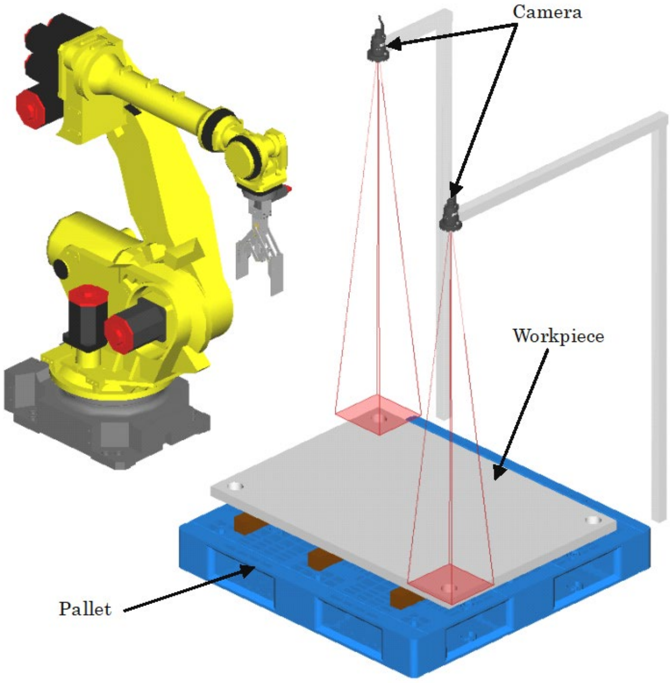
The 2D Single-view Vision Process can detect the workpiece on a plane with a camera and offset the robot position depending on the parallel movement (X, Y) direction or the rotational movement (R) direction of the workpiece. An example of the system layout is shown below. The robot detects the workpiece on the table and picks up it.



Example of layout for 2-D Single-View Vision Process

3.2 OVERVIEW OF 2D MULTI-VIEW VISION PROCESS

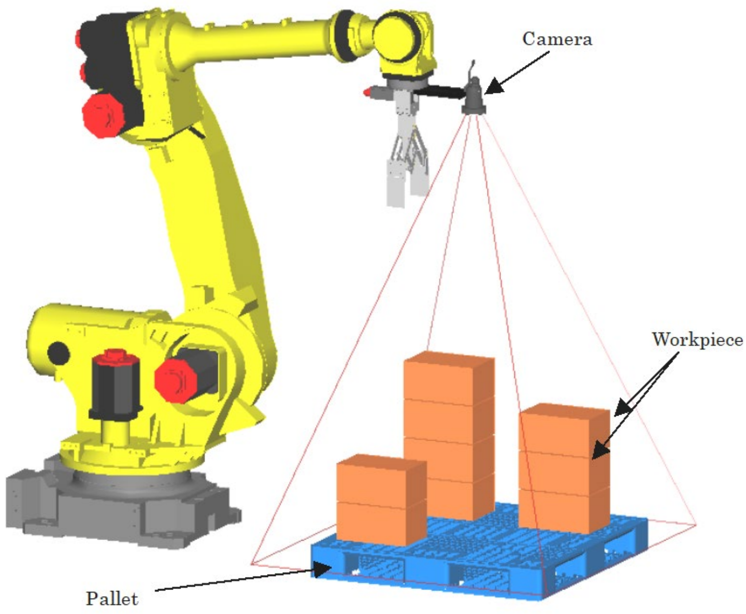
The 2D Multi-view Vision Process measures the multiple points of a workpiece and offset the robot position in the two-dimensional. This function is used to measure multiple points of a large workpiece that cannot be contained in the field of view of a single camera.
An example of the system layout is shown below. By using the two cameras, the robot detects the two corners of the large workpiece and picks up the workpiece.



Example of layout for 2-D Multi-View Vision Process

3.3 OVERVIEW OF DEPALLETIZING VISION PROCESS

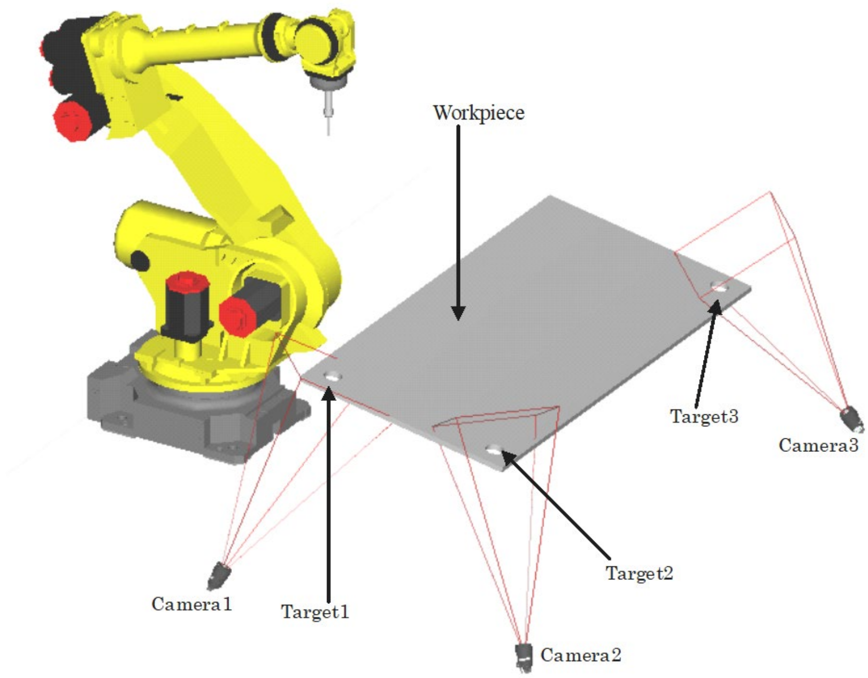
The Depalletizing Vision Process can measure not only the parallel movement of the workpiece but also the vertical direction of the workpiece. This function can measure the height of the workpieces based on the size of the workpiece in image. An example of the layout is shown below. The robot detects the stacked workpieces on the pallet and picks up there in order from the highest workpiece.



Example of layout for Depalletizing Vision Process

3.4 OVERVIEW OF 3D TRI-VIEW VISION PROCESS

The 3D Tri-View Vision Process measures the three points of a large workpiece such as a car body, and offsets the robot in the three-dimensional The offset applies to all of six degrees of freedom for parallel displacement (X, Y, Z) and rotation (W, P, R) of the workpiece. An example of the layout is shown below. The robot measures the three points of a large workpiece and offset the robot positions in the three-dimensional.



Example of layout for 3-D Tri-View Vision Process

Setup

1 2D SINGLE VIEW VISION PROCESS

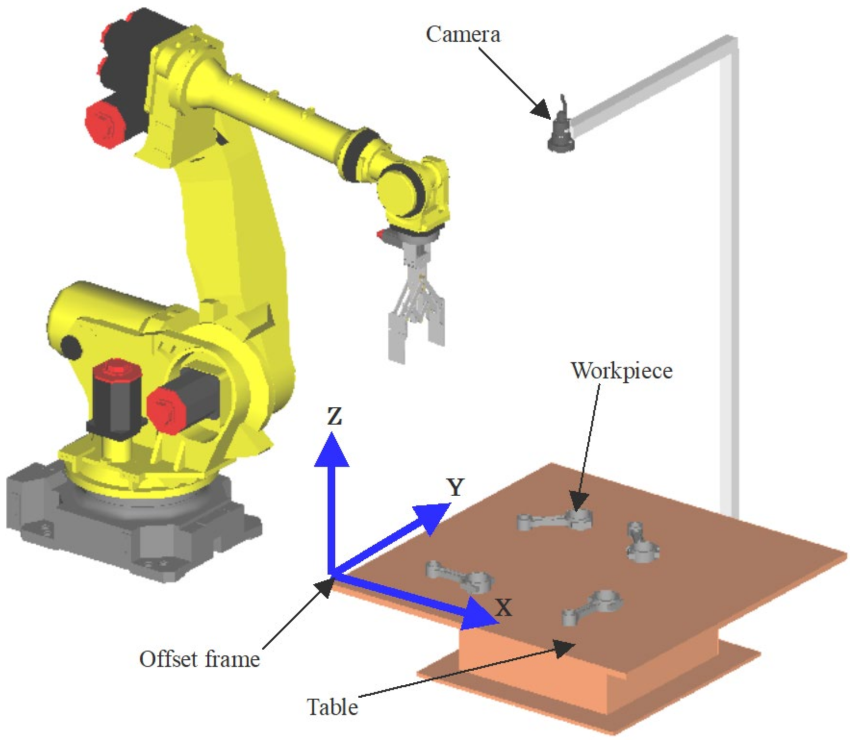
The 2D Single-view Vision Process can detect the workpiece on a plane with a camera and offset the robot position depending on the parallel movement (X, Y) direction or the rotational movement (R) direction of the workpiece. The 2D Single-view Vision Process can be used in the following four configurations:

- Fixed frame offset with a fixed camera
- Fixed frame offset with a robot-mounted camera
- Tool offset with a fixed camera
- Tool offset with a robot-mounted camera

This chapter describes the setup procedure for a 2D Single-view Vision Process by using the following three application examples: 'Fixed frame offset with a fixed camera', 'Fixed frame offset with a robot-mounted camera' and 'Tool offset with a fixed camera'.
In the configuration of 'Tool offset with a robot-mounted camera', a robot A holds the camera and robot B holds the workpiece, and the robot A measures the grip error of the workpiece. The current position of each robot is needed, so the inter-robot communication function should be set to communicate between each robot. If a robot A is held a camera but it used as a fixed camera, the setup procedures is same as 'Tool offset with a fixed camera'.

Fixed frame offset with a fixed camera

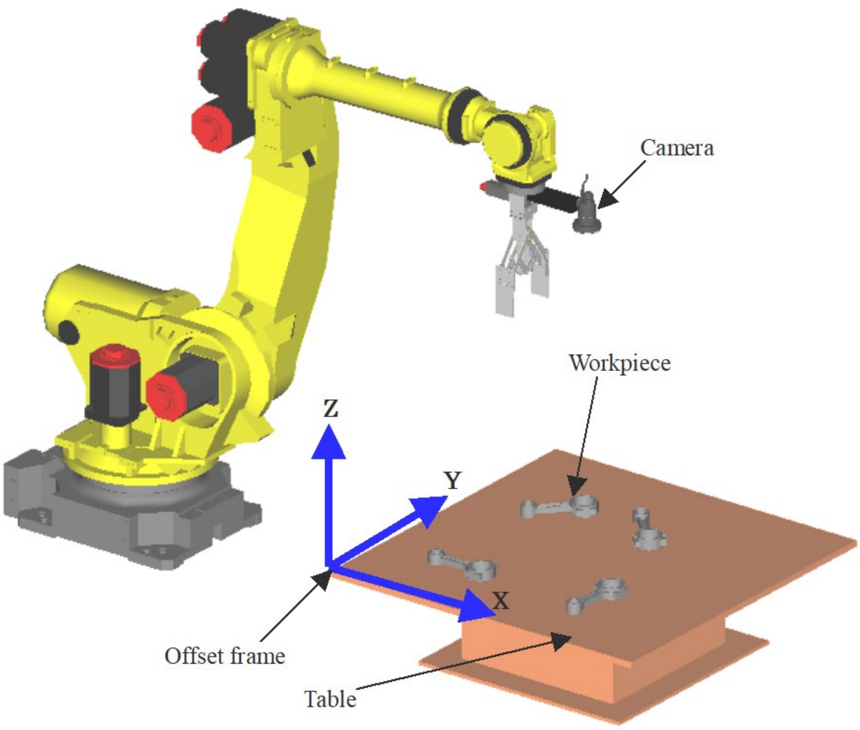
An example of a layout for a 'fixed frame offset with a fixed camera' is shown below.



Example of a layout for a fixed frame offset with a fixed camera

Fixed frame offset with a robot-mounted camera

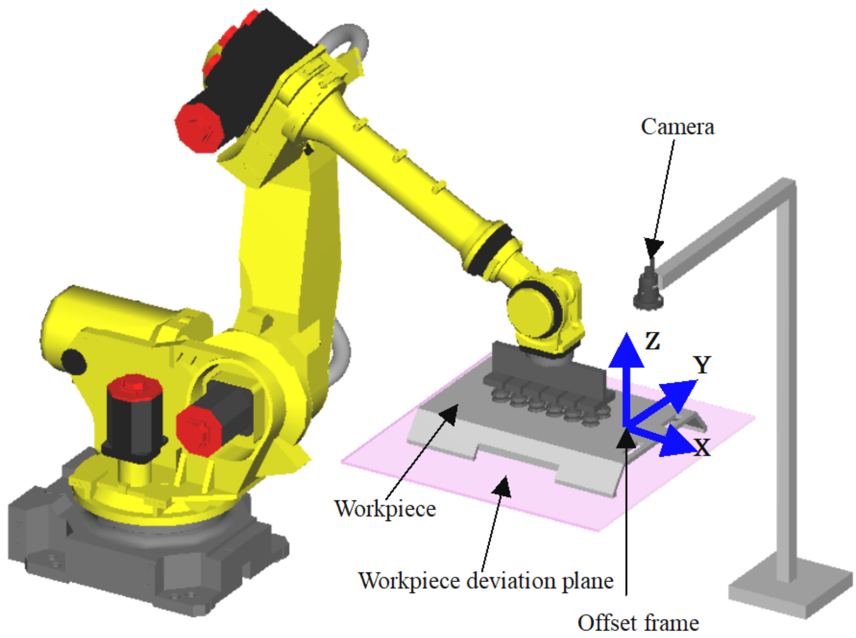
An example of a layout for a 'fixed frame offset with a robot-mounted camera' is shown below.



Example of a layout for 'a fixed frame offset with a robot-mounted camera'

Tool offset with a fixed camera

An example of a layout for a 'tool offset with a fixed camera' is shown below.



Example of a layout for a tool offset with a fixed camera

1.1 FEATURES AND NOTES

Features

- 2D single-view vision process is the most standard application of a 2-D view vision process.
- It supports the fixed frame offset and the tool offset.
- Both a fixed camera and a robot-mounted camera can be used.
- When a robot-mounted camera is used, even if when the robot moves the camera in the X and Y directions on the offset frame, the position of a workpiece can be measured. This is because, *i*RVision calculates the positions of the workpiece based on the current position of the robot.

> **Memo**
> With a controller that can use a tablet TP, 2-D Single-View Vision Process can also be taught using a tablet TP. For details, Refer to “Tablet UI OPERATOR’S MANUAL B-84274EN”.

Notes

- The offset is applied to the XY and R directions. Therefore, each measurement plane should be parallel to the XY plane of the offset frame and should not be tilted.
- Ideally, the optical axis of the camera should be vertical to the XY plane of the offset frame. When the position of the camera is tilted against the measurement points of the workpiece, the shape of the workpiece in the image may change depending on the location of the workpiece, so the detection may become difficult.

1.2 SETUP FOR FIXED FRAME OFFSET WITH FIXED CAMERA

The setup procedures for the fixed frame offset with the fixed camera is shown below:

1. Camera Data Creation and Teaching

⇩

2. Offset frame setting

⇩

3. Vision process creation and teaching

⇩

4. Robot program creation and teaching

⇩

5. Robot compensation operation check

When create the vision system newly, perform all of the above procedures. When the position of the installed camera is changed or the cameras are exchanged, redo the camera calibration in ‘1 Camera Data Creation and Teaching’. When you need to add a new kind of workpiece, if a camera calibration has been already done, the re-calibration of the camera is not needed. Perform '3 Vision process creation and teaching' and '4 Robot program creation and teaching'.

1.2.1 Camera Data Creation and Teaching

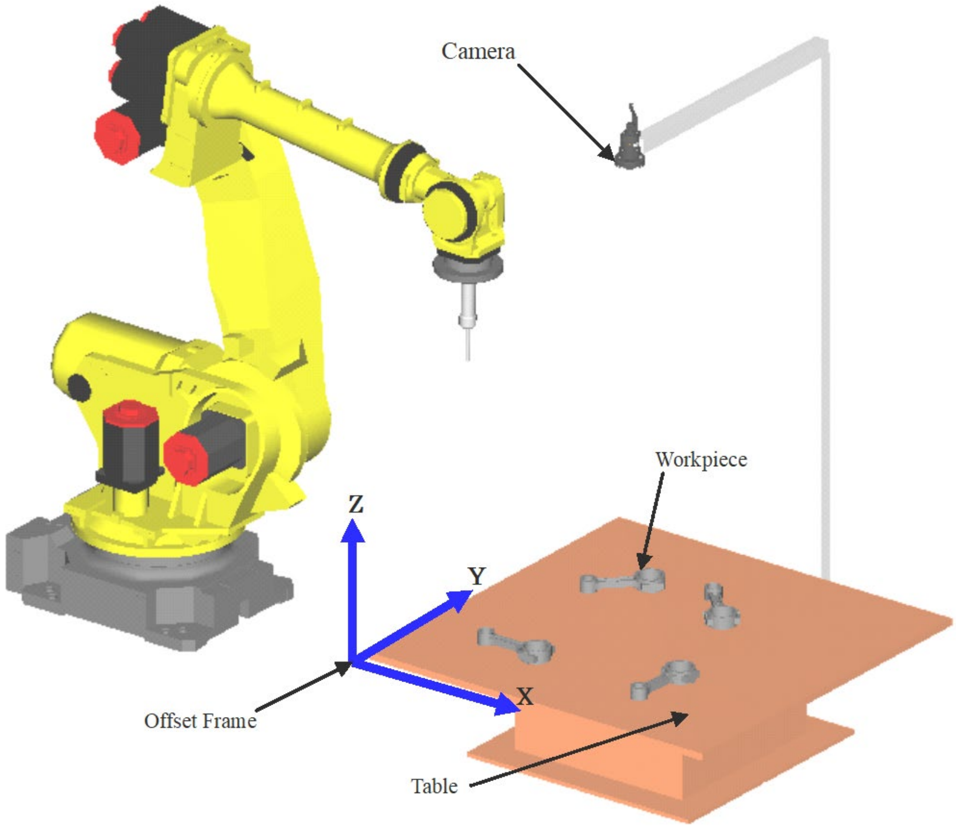
Create a camera data and perform basic settings and calibration of the camera.

The Grid Pattern Calibration and the Robot-generated Grid Calibration can be used to calibrate a fixed camera.

- For details of the grid pattern calibration, refer to Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA".
- For details of robot-generated grid calibration, refer to Know-how Edition Section 2.3, "ROBOT-GENERATED GRID CALIBRATION".

1.2.2 Offset Frame Setting

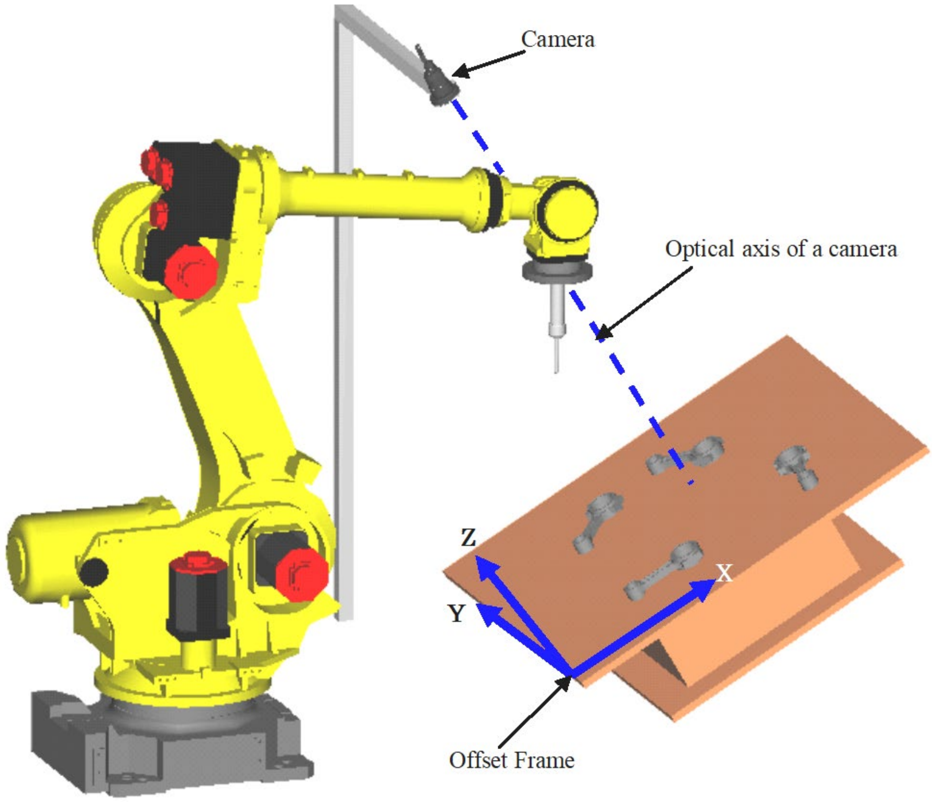
The offset frame is used for the calculation of the offset data in the 2D Single-view Vision Process. The position of a found workpiece is outputted as the position on the offset frame. In the fixed frame offset, the offset frame is set as a user frame.
Set an offset frame so that the XY plane of the offset frame is parallel with the table plane where the workpiece is placed. When the offset frame is not parallel with the plane where the workpiece is placed, the accuracy of offset may become low.



Offset Frame setting

In the following figure, the plane where the workpieces are placed is tilted against the robot's world frame.

Set the offset frame so that the plane where the workpieces are placed is parallel with the XY plane of the offset frame.



Offset Frame setting (When an inclined work table is installed)

There are two methods for configuring the frame settings used in compensation: using the frame value and automatic measuring.
There are two methods for using the frame value: setting using “Touch-up” and setting using “Grid Frame Setting”.

Touch-up (Use the Frame Value)

When set the user frame by touch-up method, a pointer tool with TCP is needed. In general, attach the pointer tool to the robot hand and set the TCP accurately at the tip of the pointer tool. If the accuracy of TCP setting is low, the accuracy of the offset is also degraded. Set a TCP in an arbitrary tool frame. When you reuse the pointer tool later, install the pointer tool in where the same location as when the TCP setting had performed. If the reproducibility of pointer installation is not assured, a TCP setting needs again. For details, refer to Know-how Edition Subsection 1.1.1, "User Frame Setting".

Grid Frame Setting Function (Use the Frame Value)

The Grid Frame Setting Function sets the user frame on the calibration grid frame by using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane where the workpiece is placed, and perform the Grid Frame Setting Function. For details, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION". When a fixed camera is used, prepare another temporary camera to perform the Grid Frame Setting Function. The Grid Frame Setting Function can be only used with the 6-axis robot. This function cannot be used with the 4-axis robot and the 5-axis robot. When the 4-axis robot or the 5-axis robot is used, use the touch-up method.

Measure Automatically

Set the placement information of the calibration grid using the camera. Unlike the grid frame setting, the robot does not move automatically for the frame setting. For the detailed setting procedure, refer to the description of automatic setting of the offset frame in “*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN”.

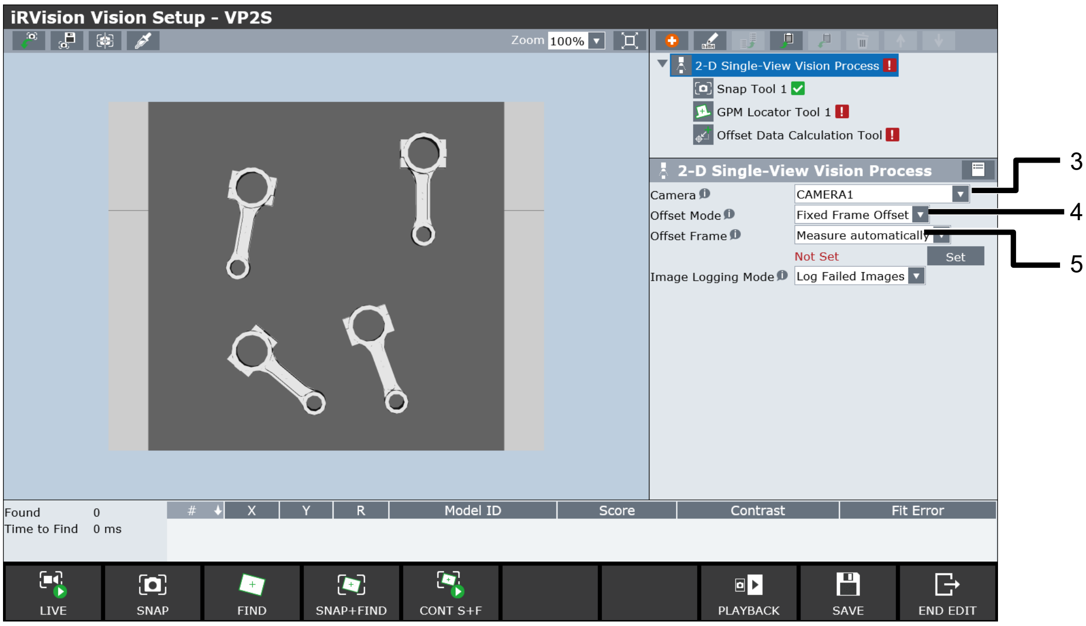
1.2.3 Vision Process Creation and Teaching

Create a vision process and teach it. In addition, teach the locator tools and set the reference position.

1.2.3.1 Vision process creation

1 Create a vision process for [2-D Single-View Vision Process].
For details of the vision process creation, refer to the description of creating new vision data in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, when a created vision process is selected and clicked [Edit], the vision data edit screen will appear.



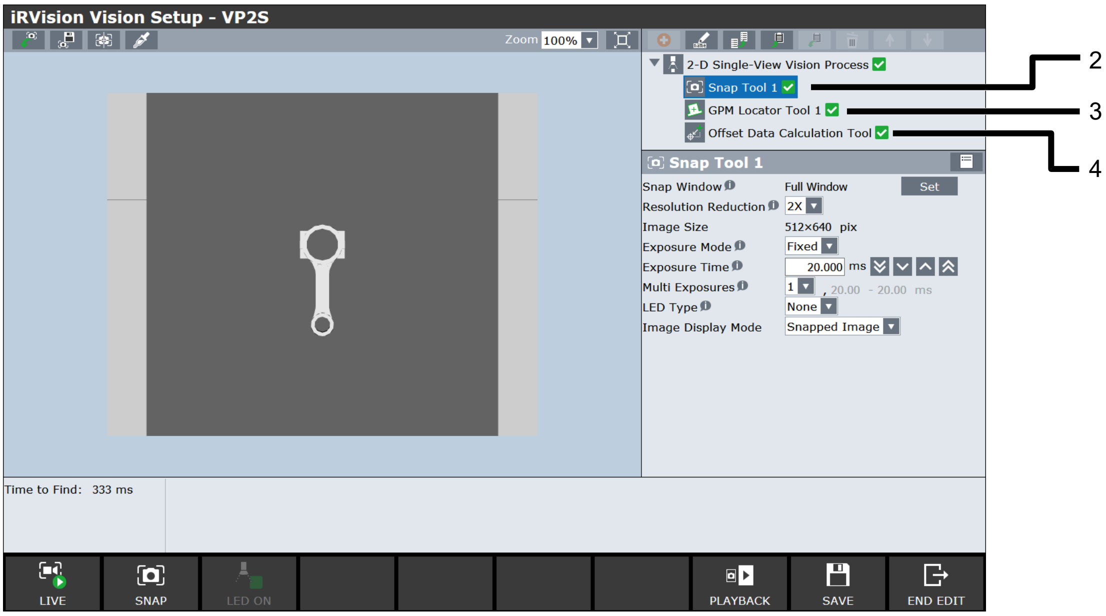
3 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 1.2.1, "Camera Data Creation and Teaching".

4 From the [Offset Mode] drop-down box, select [Fixed Frame Offset].

5 From the [Offset Frame] drop-down box, select the user frame to set or "Measure automatically".
Refer to Setup Edition Subsection 1.2.2, "Offset Frame Setting" for the setting methods.

1.2.3.2 Command tool teaching

1 Place a workpiece in the field of view of the camera.



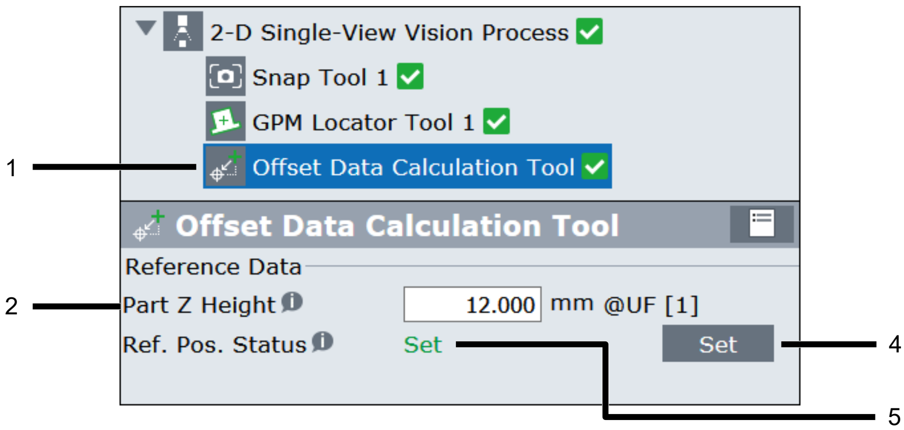
2 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap window and the exposure time. For details, refer to the description of Snap Tool in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

3 Select a locator tool from the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details of the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

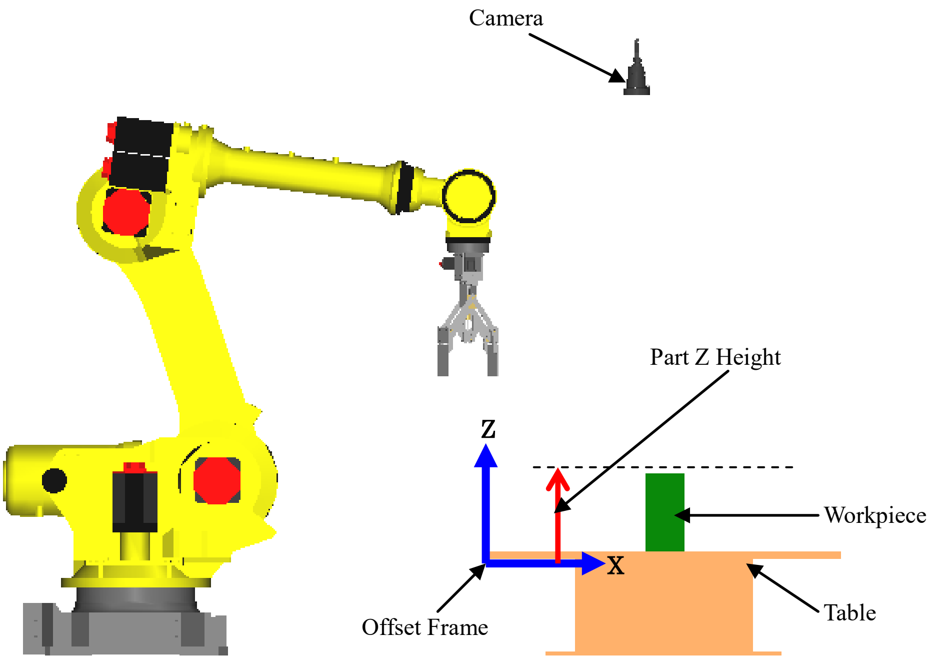
4 When the snap tool and the locator tool are set, set the reference position in the offset data calculation tool. Refer to 1.2.3.3, "Reference position setting" for the setting.

1.2.3.3 Reference position setting

1 Select [Offset Data Calculation Tool] from the tree view.



2 In the text box for [Part Z Height], enter the height of the detected part of the workpiece.
When the XY plane of the offset frame is apart from the detected part of the workpiece, enter the distance.
Enter an appropriate value as shown in the figure below.



Offset Frame and Part Z Height

3 Click [SNAP] and snap the image, and click [FIND] to detect the workpiece.

> ⚠ **CAUTION**
> Do not move the workpiece until the reference position setting is complete.

4 Click the [Set] button for [Ref. Pos. Status]
5 Check if [Ref. Pos. Status] is [Set].
6 Click [SAVE] and click [END EDIT].
7 Move the robot to the position where work to the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 1.2.4, "Robot Program Creation and Teaching". P[2] in line 11 is the position to work to the workpiece. Record the current robot position to P[2], and the reference position setting is complete.

1.2.4 Robot Program Creation and Teaching

The sample program is shown below. A vision process "A" is used. Add the "VOFFSET, VR" instruction to the movement statement.

```
 1:    UFRAME_NUM=1 ;
 2:    UTOOL_NUM=1 ;
 3:    R[1:Notfound]=0      ;
 4:L P[1] 2000mm/sec FINE      ;
 5:     ;
 6:    VISION RUN_FIND 'A'      ;
 7:    VISION GET_OFFSET 'A' VR[1] JMP LBL[100] ;
 8:     ;
 9:    !Handling ;
10:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]      ;
11:L P[2] 500mm/sec FINE VOFFSET,VR[1]      ;
12:    CALL HAND_CLOSE      ;
13:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]      ;
14:    !Handling ;
15:    JMP_LBL[900] ;
16:     ;
17:    LBL[100] ;
18:    R[1:Notfound]=1      ;
19:     ;
20:    LBL[900] ;
```

Execute the vision program "A" on line 6. Obtain the offset data on line 7. Move the robot to the approach position above the workpiece on line 10. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move the robot to the grasp position on line 11. Move the robot to escape position after grasping the workpiece on line 13.

1.2.5 Robot Compensation Operation Check

Check that a placed workpiece on the table can be detected and handled accuracy.

- Place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of the offset is low, set the reference position again.
- Move the workpiece without rotation, find it and check the handling accuracy. If the accuracy of the offset is good on the reference position but it lows on the edge of the field of view, it is possible that [Part Z Height] is not set properly. Check the [Part Z Height], refer to Setup Edition Subsection 1.2.3.3, "Reference position setting".
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy of the offset is good on the non-rotated workpiece but it lows on rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. When set the frames using the touch-up method with a pointer tool, check the TCP setting is precise. Moreover, check the offset frame and calibration grid frame are set precisely. If there is necessary, retry the camera calibration. If it is difficult to retry the camera calibration, the "ADJ_OFS" may improve the situation without the re-set up the offset frame and the calibration grid location. ADJ_OFS is included in VISION SUPPORT TOOLS. Refer to the description of "ADJ_OFS" in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN" for details.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

1.3 SETUP FOR FIXED FRAME OFFSET WITH ROBOT MOUNTED CAMERA

The setup procedures for the fixed frame offset with the robot mounted camera is shown below:

1. Camera Data Creation and Teaching

⇩

2. Offset frame setting

⇩

3. Vision process creation and teaching

⇩

4. Robot program creation and teaching

⇩

5. Robot compensation operation check

When create the vision system newly, perform all of the above procedures. When the position of the camera on the robot mechanical interface (the robot face plane) is changed or the cameras are exchanged, redo the camera calibration in '1 Camera Data Creation and Teaching'. When you need to add a new kind of workpiece, if a camera calibration has been already done, the re-calibration of the camera is not needed. Perform '3 Vision process creation and teaching' and '4 Robot program creation and teaching'.

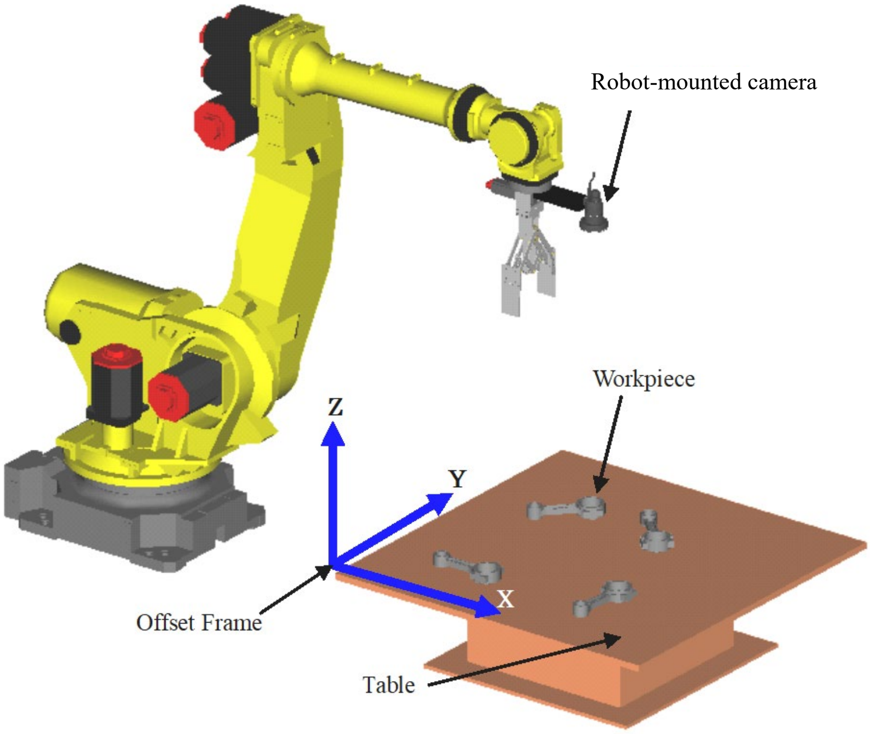
1.3.1 Camera Data Creation and Teaching

Create a camera data and perform basic settings and calibration for the camera.

When a robot-mounted camera is used, perform the 'Grid Pattern Calibration'. When a robot-mounted camera is used, the 'Robot-Generated Grid Calibration' cannot be used. For details of the grid frame calibration, refer to Know how Edition Section 2.2, "GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA".

1.3.2 Offset Frame Setting

The offset frame is used for the calculation of the offset data in the 2D Single-view Vision Process. The position of a found workpiece is outputted as the position on the offset frame. In the fixed frame offset, the offset frame is set as a user frame.
Set an offset frame so that the XY plane of the offset frame is parallel with the table plane where the workpiece is placed. When the offset frame is not parallel with the plane where the workpiece is placed, the accuracy of offset may become low.



Offset Frame setting

There are two methods for configuring the frame settings used in compensation: using the frame value and automatic measuring.
There are two methods for using the frame value: setting using "Touch-up" and setting using "Grid Frame Setting". When using a robot-mounted camera, the automatic measuring method is recommended.

Touch-up (Use the Frame Value)

When set the user frame by touch-up method, a pointer tool with TCP is needed. In general, attach the pointer tool to the robot hand and set the TCP accurately at the tip of the pointer tool. If the accuracy of TCP setting is low, the accuracy of the offset is also degraded. Set a TCP in an arbitrary tool frame. When you reuse the pointer tool later, install the pointer tool in where the same location as when the TCP setting had performed. If the reproducibility of pointer installation is not assured, a TCP setting needs again. For details, refer to Know-how Edition Subsection 1.1.1, "User Frame Setting".

Grid Frame Setting Function (Use the Frame Value)

The Grid Frame Setting Function sets the user frame on the calibration grid frame by using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane where the workpiece is placed, and perform the Grid Frame Setting Function. For details, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION". When a robot-mounted camera is used, the camera can be used for the Grid Frame Setting Function. When there is not sufficient space to perform the Grid Frame Setting Function with the camera, prepare another temporary robot-mounted camera and perform the Grid Frame Setting Function. The Grid Frame Setting Function can be only used with the 6-axis robot. This function cannot be used with the 4-axis robot and the 5-axis robot. When the 4-axis robot or the 5-axis robot is used, use the touch-up method.

Measure Automatically

Set the placement information of the calibration grid using the camera. Unlike the grid frame setting, the robot does not move automatically for the frame setting. For the detailed setting procedure, refer to the description of automatic setting of the offset frame in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

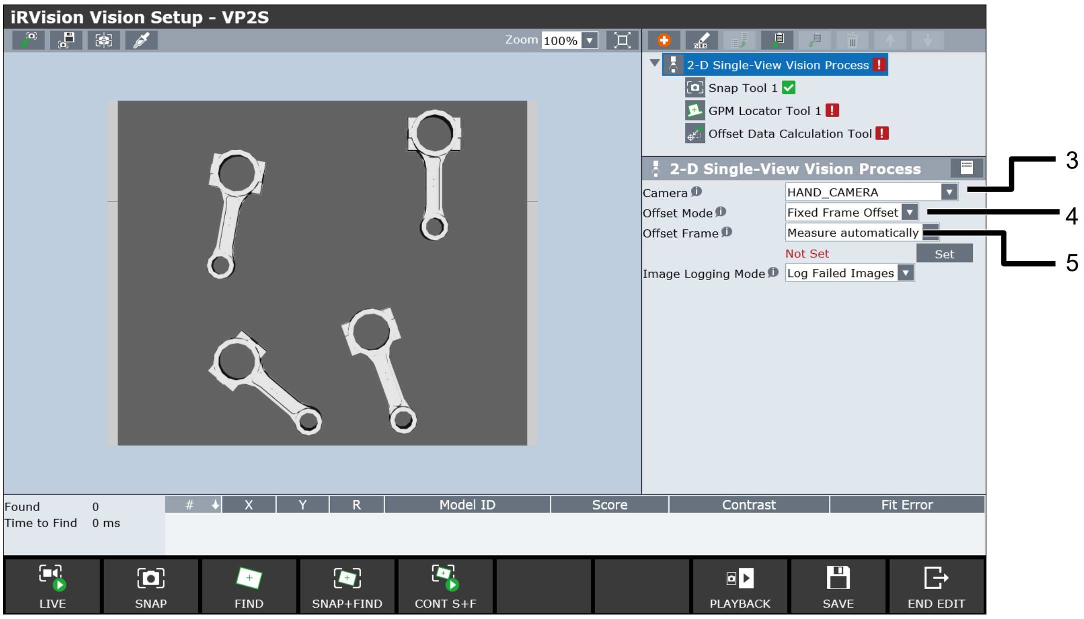
1.3.3 Vision Process Creation and Teaching

Create a vision process and teach it. In addition, teach the locator tools and set the reference position.

1.3.3.1 Vision process creation

1 Create a vision process for [2-D Single-View Vision Process].
For details of the vision process creation, refer to the description of creating new vision data in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, when the created vision process is selected and clicked [Edit], the vision data edit screen will appear.



3 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 1.3.1, "Camera Data Creation and Teaching".

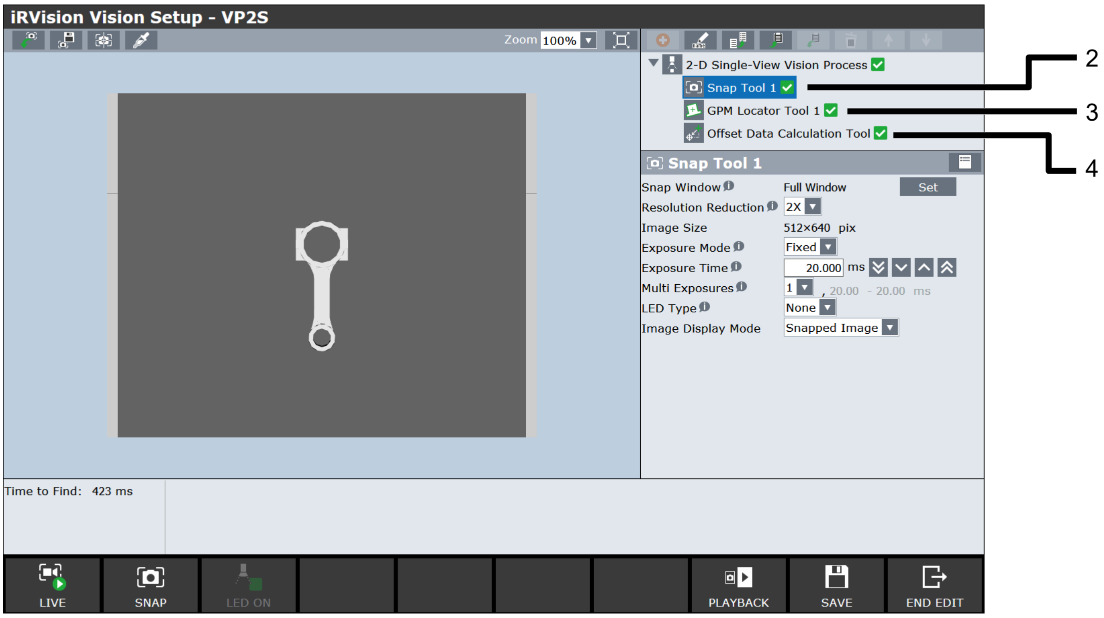
4 From the [Offset Mode] drop-down box, select [Fixed Frame Offset].

5 From the [Offset Frame] drop-down box, select the user frame to set or "Measure automatically".
Refer to Setup Edition Subsection 1.3.2, "Offset Frame Setting" for the setting methods.

1.3.3.2 Command tool teaching

1 Place a workpiece in the field of view of the camera.

2 Move the robot to the measurement position where the workpiece can be snapped.
Record this robot position as the first measurement position. Refer to the sample program in Setup Edition Subsection 1.3.4, "Robot Program Creation and Teaching". P[1] in line 4 is the first measurement position. Record the current robot position to P[1].



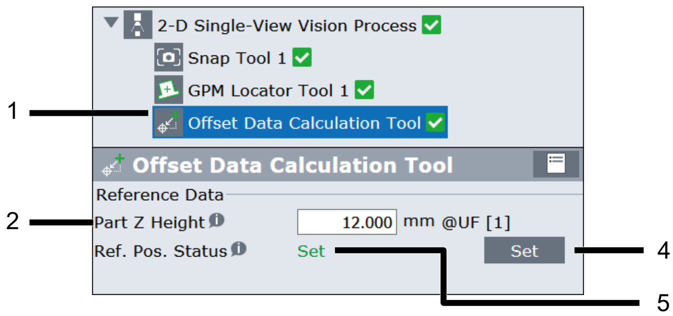
3 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap window and the exposure time. For details, refer to the description of Snap Tool in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

4 Select a locator tool from the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details of the GPM Locator Tool and other command tools, refer to the description of Command Tools in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

5 When the snap tool and the locator tool are set, set the reference position in the offset data calculation tool. Refer to 1.3.3.3, "Reference position setting" for the setting.

1.3.3.3 Reference position setting

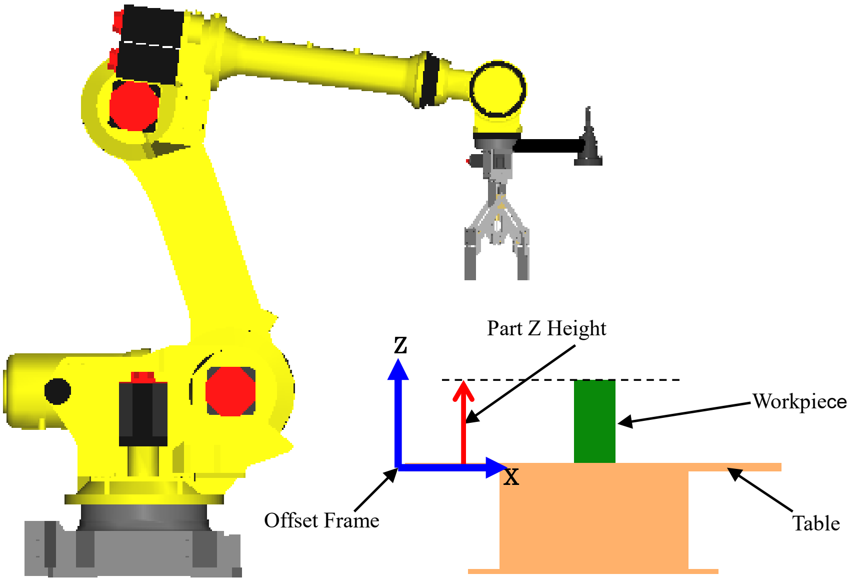
1 Select [Offset Data Calculation Tool] from the tree view.



2 In the text box for [Part Z Height], enter the height of the detected part of the workpiece.
When the XY plane of the offset frame is apart from the detected part of the workpiece, enter the distance.

3 Click [SNAP] and snap the image, and click [FIND] to detect the workpiece.

> ⚠ **CAUTION**
> Do not move the workpiece until the reference position setting is complete.



Offset Frame and Part Z Height

4 Click the [Set] button for [Ref. Pos. Status]
5 Check if [Ref. Pos. Status] is [Set].
6 Click [SAVE] and click [END EDIT].
7 Move the robot to the position where work to the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 1.3.4, "Robot Program Creation and Teaching". P[2] in line 11 is the position to work to the workpiece. Record the current robot position on P[2], and reference position setting is complete.

1.3.4 Robot Program Creation and Teaching

The sample program is shown below. A vision process "A" is used. Add the "VOFFSET, VR" instruction to the movement statement.

```
 1:    UFRAME_NUM=1 ;
 2:    UTOOL_NUM=1 ;
 3:    R[1:Notfound]=0       ;
 4:L P[1] 2000mm/sec FINE      ;
 5:    WAIT R[1] ;
 6:    VISION RUN_FIND 'A'      ;
 7:    VISION GET_OFFSET 'A' VR[1] JMP LBL[100] ;
 8:      ;
 9:    !Handling ;
10:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]      ;
11:L P[2] 500mm/sec FINE VOFFSET,VR[1]       ;
12:    CALL HAND_CLOSE      ;
13:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]      ;
14:    !Handling ;
15:    JMP_LBL[900] ;
16:      ;
17:    LBL[100] ;
18:    R[1:Notfound]=1       ;
20:      ;
21:    LBL[900] ;
```

On line 4, move a camera to the snapping position. Execute a "WAIT" instruction to remove the vibration of a camera on line 5. Execute the vision program [A] on line 6. Obtain the offset data on line 7. Move the robot to approach position above the workpiece on line 10. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move the robot to grasp position on line 11. Move the robot to the escape position after grasping the workpiece on line 13.

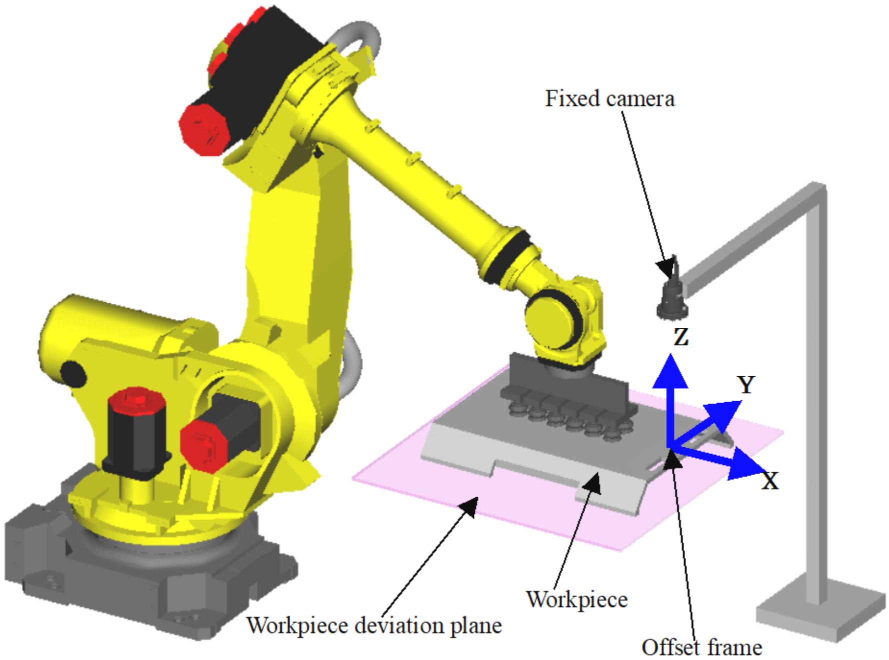
1.3.5 Robot Compensation Operation Check

Check that a placed workpiece on the table can be detected and handled accuracy.

- Place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of the offset is low, set the reference position again.
- Move the workpiece without rotation, find it and check the handling accuracy. If the offset accuracy is good on the reference position but it lows on the edge of the field of view, it is possible that ‘Part Z Height’ is not set properly. Check the [Part Z Height], refer to Setup Edition Subsection 1.3.3.3, "Reference position setting".
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy of the offset is good on the non-rotated workpiece but it lows on rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. When set the frames using the touch-up method with a pointer tool, check the TCP setting is precise. Moreover, check the offset frame and calibration grid frame are set precisely. If there is necessary, retry the camera calibration. If it is difficult to retry the camera calibration, the ADJ_OFS may improve the situation without the re-set up the offset frame and the calibration grid frame. ADJ_OFS is included in VISION SUPPORT TOOLS. Refer to the description of "ADJ_OFS" in the "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN" for details.
- Depending on robot motion, a camera may vibrate at snap position. Execute "WAIT" instruction to remove the possible vibration of a workpiece before the detection.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

1.4 SETUP FOR TOOL OFFSET WITH FIXED CAMERA

Snap a gripped workpiece by the robot with misaligned, and measure the amount of the misaligned. The robot places the workpiece accurately to the specified position.
An example layout of "tool offset with fixed camera" is shown below:



Example of a layout for a tool offset with a fixed camera

The setup procedures for the tool offset with thefixed camera is shown below:

1. Camera Data Creation and Teaching

⇩

2. Offset frame setting

⇩

3. Vision process creation and teaching

⇩

4. Robot program creation and teaching

⇩

5. Robot compensation operation check

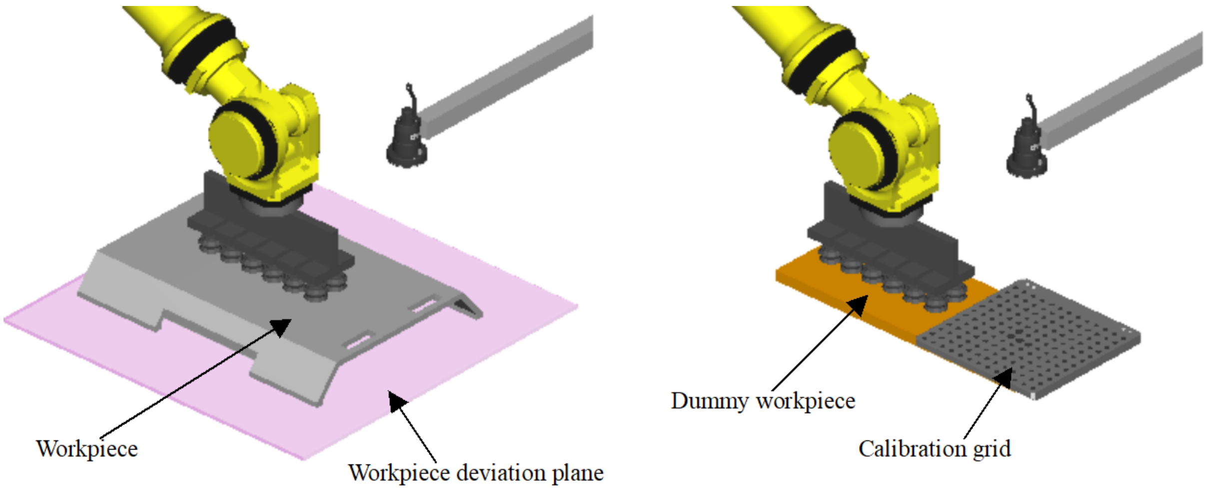
When create the vision system newly, perform all of the above procedures. When the position of the camera is changed or the cameras are exchanged, redo the camera calibration in ‘1 Camera Data Creation and Teaching’. When you need to add a new kind of workpiece, if a camera calibration has been already done, the re-calibration of the camera is not needed. Perform ‘3 Vision process creation and teaching’ and ‘4 Robot program creation and teaching’.

1.4.1 Camera Data Creation and Teaching

Create a camera data and perform basic settings and calibration for the camera.
The Grid Pattern Calibration and the Robot-generated Grid Calibration can be used to calibrate a fixed camera.

Grid Pattern Calibration

When the Grid Pattern Calibration is used for the calibration of tool offset, it is recommended to set the calibration grid on a dummy workpiece. In the following figures, the calibration grid is installed on the same position as the measurement position of workpiece. Prepare a dummy workpiece so that it can be gripped instead of an actual workpiece, and install the calibration grid on the dummy workpiece. By using this method, setup of the offset frame can be simplified.



How to attach a calibration grid

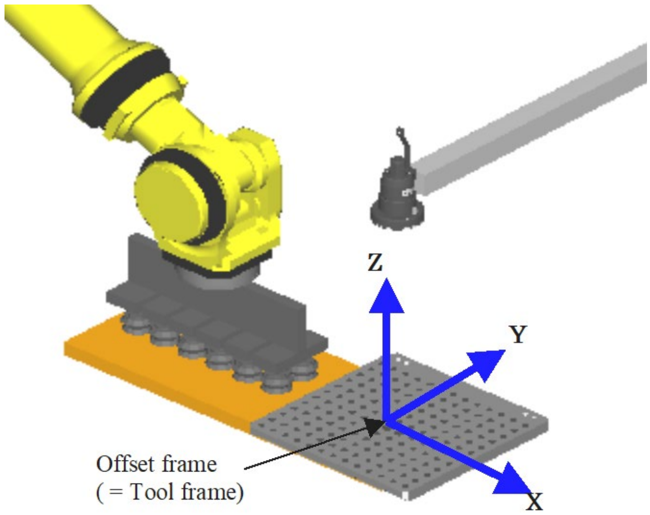
When install a calibration grid so that the XY plane of the calibration grid is parallel with the plane where a workpiece moves, a setup of the offset frame becomes easy. For details of the grid frame calibration, refer to Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA".

Robot-generated Grid Calibration

When the robot-generated grid calibration is used for the calibration of tool offset, it is recommended to attach a target mark to a dummy workpiece for calibration. Prepare a dummy workpiece so that it can be gripped instead of an actual workpiece, and install the target mark on the dummy workpiece. By using this method, setup of the offset frame can be simplified. Set a target mark so that the XY plane of the target mark is parallel with the plane on where a workpiece moves.
For details of the Robot-generated Grid Calibration, refer to Know-how Edition Section 2.3, "ROBOT-GENERATED GRID CALIBRATION".

1.4.2 Offset Frame Setting

The offset frame is used for the calculation of the offset data in the 2D Single-view Vision Process. A found position is outputted as a position on the offset frame. In the fixed frame offset, the offset frame is set as a user frame, but in the tool offset, it is set as a tool frame.
Set a tool frame so that the XY plane of the tool frame is parallel with the workpiece deviation plane.
When the Grid Pattern Calibration is used, if the XY plane of the tool frame that is set in Know-how Edition Subsection 2.1.4, "Calibration" is parallel with the workpiece deviation plane, the tool frame can be used as the offset frame.



Offset frame setting

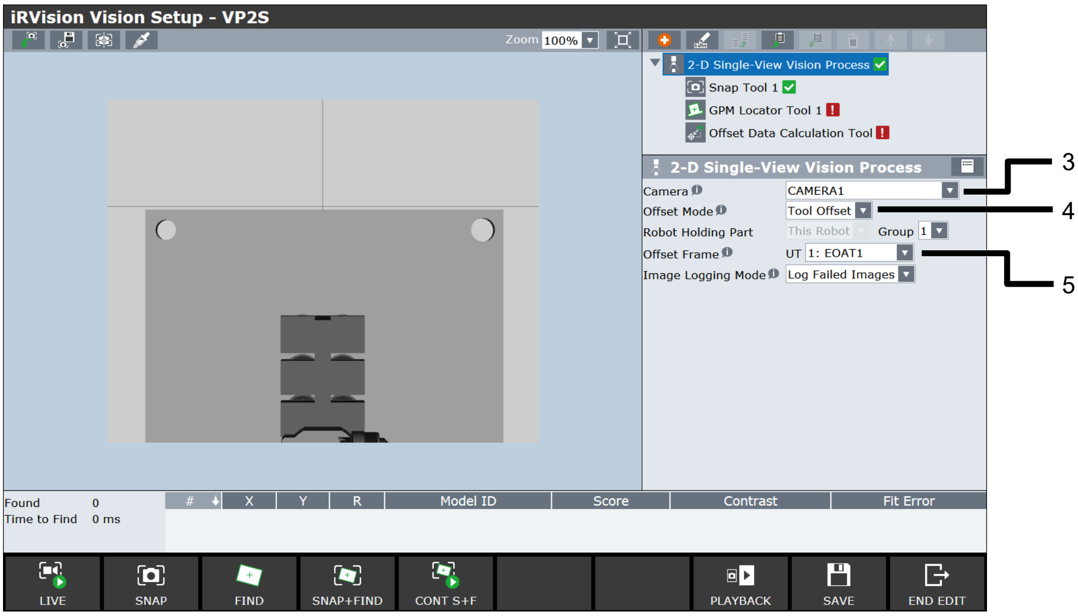
When the Robot-generated Grid Calibration is used, if the XY plane of the tool frame (UTool for work space) that is set in Know-how Edition Subsection 2.3.8, "Measuring target position" is parallel with the deviation plane of the workipece, the tool frame can be used as the offset frame. In this case, it is recommended to copy the values of the UTool for work space to another tool frame number and specify it as the offset frame number. For example, when the UTool for work space number is 9, copy the value of the UTool for work space to arbitrary another tool frame numbers (for example, the tool frame number is 1), and select the tool frame number as the offset frame.

1.4.3 Vision Process Creation and Teaching

Create a vision process and teach it. In addition, teach the locator tools and set the reference position.

1.4.3.1 Vision process creation

1. Create a vision process for [2-D Single-View Vision Process].
   For details of the vision process creation, refer to the description of creating new vision data in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".
2. On the vision data list screen, when the created vision process is selected and clicked [Edit], the vision data edit screen will appear.



3 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 1.4.1, "Camera Data Creation and Teaching".

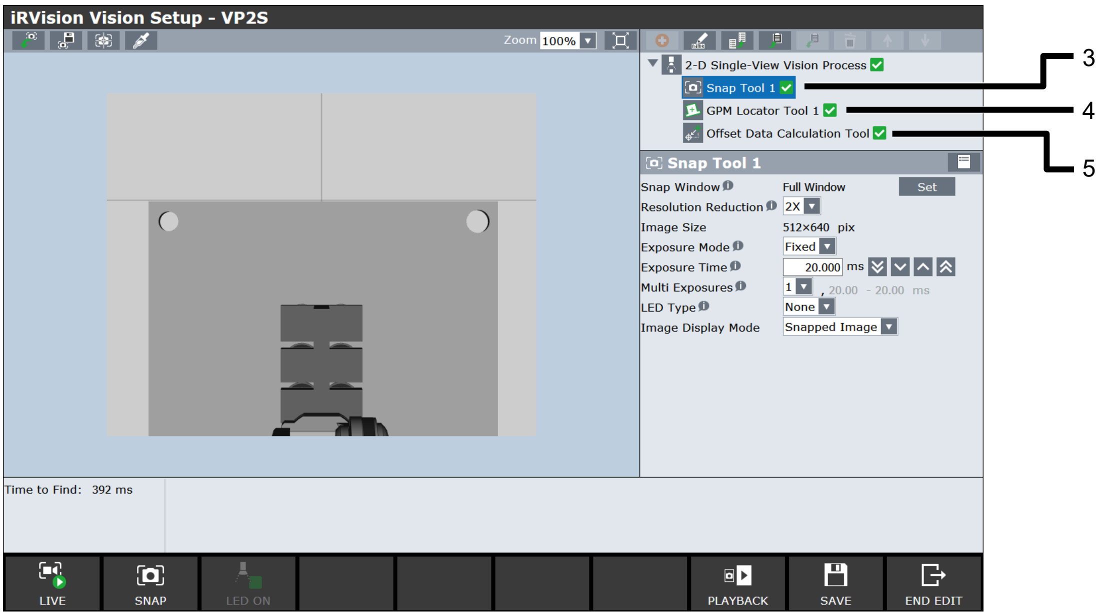
4 From the [Offset Mode] drop-down box, select [Tool Offset].

5 From the [Offset Frame] drop-down box, select the tool frame to set.
Select the frame number specified in Setup Edition Subsection 1.4.2, "Offset Frame Setting".

1.4.3.2 Command tool teaching

1 Place a workpiece in the field of view of the camera.

2 Move the robot to the measurement position where the workpiece can be snapped.



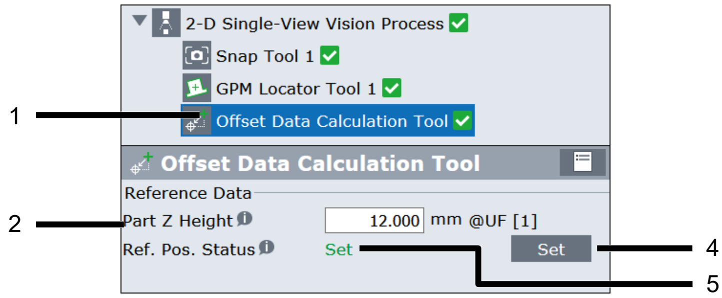
3 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap window and the exposure time. For details, refer to the description of Snap Tool in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

4 Select a locator tool from the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details of the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

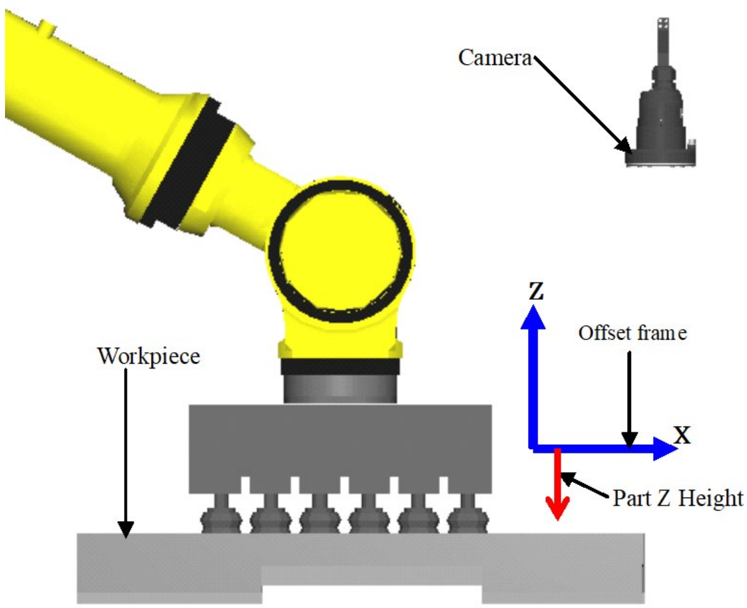
5 When the snap tool and the locator tool are set, set the reference position in the offset data calculation tool. Refer to 1.4.3.3, "Reference position setting" for the setting.

1.4.3.3 Reference position setting

1 Select [Offset Data Calculation Tool] from the tree view.



2 In the text box for [Part Z Height], enter the height of the detected part of the workpiece.
When the XY plane of the offset frame is apart from the detected part of the workpiece, enter the distance.
Enter an appropriate value as shown in the figure below.



Offset frame and Part Z Height

3 Click [SNAP] and snap the image, and click [FIND] to detect the workpiece.

> ⚠ **CAUTION**
> Do not move the workpiece until the reference position setting is complete.

4 Click the [Set] button for [Ref. Pos. Status].

5 Check if [Ref. Pos. Status] is [Set].
6 Click [SAVE] and click [END EDIT].
7 Move the robot to the position to work to the workpiece (e.g. place it).
For an example, refer to the sample program in Setup Edition Subsection 1.4.4, "Robot Program Creation and Teaching". P[2] in line 11 is the position to work to the workpiece. Record the current robot position on P[2], and the reference position setting is complete.

1.4.4 Robot Program Creation and Teaching

The sample program is shown below. A vision process "A" is used. Add the "VOFFSET, VR" instruction to the movement statement.

```
 1:     UFRAME_NUM=1 ;
 2:     UTOOL_NUM=6 ;
 3:     R[1:Notfound]=0       ;
 4:L P[1] 2000mm/sec FINE       ;
 5:     WAIT R[1] ;
 6:     VISION RUN_FIND 'A'       ;
 7:     VISION GET_OFFSET 'A' VR[1] JMP LBL[100] ;
 8:      ;
 9:     !Handling ;
10:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Offset,PR[1]       ;
11:L P[2] 500mm/sec FINE VOFFSET,VR[1]       ;
12:     CALL HAND_OPEN       ;
13:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Offset,PR[3]       ;
14:     !Handling ;
15:     JMP_LBL[900] ;
16:      ;
17:     LBL[100] ;
18:     R[1:Notfound]=1       ;
19:      ;
20:     LBL[900] ;
```

On line 4, move a workpiece to the snapping position. Execute a "WAIT" instruction to remove the vibration of the workpiece on line 5. Execute vision process [A] on line 6. Obtain the offset data on line 7. Move the robot to the approach position to place the workpiece on line 10. Since this is the approach position, add the position offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece position). Move the robot to the position to place the workpiece on line 11. Move the robot to the escape position after the workpiece is placed on line 13.

1.4.5 Robot Compensation Operation Check

Check that a gripped workpiece by the robot can be detected and placed accuracy.

- Place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of the offset is low, set the reference position again.
- Move the workpiece without rotation, find it and check the handling accuracy. If the accuracy of the offset is good on the reference position but it lows on the edge of the field of view, it is possible that [Part Z Height] is not set properly. Check the [Part Z Height], refer to Setup Edition Subsection 1.4.3.3, "Reference position setting".
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy of the offset is good on the non-rotated workpiece but it lows on rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. When set the frames using the touch-up method with a pointer tool, check the TCP setting is precise. Moreover, check the offset frame and calibration grid frame are set precisely. If there is necessary, retry the camera calibration.

- Depending on robot motion, a workpiece may vibrate at snap position. Execute "WAIT" instruction to remove the vibration of a workpiece before the detection.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

2 2D MULTI VIEW VISION PROCESS

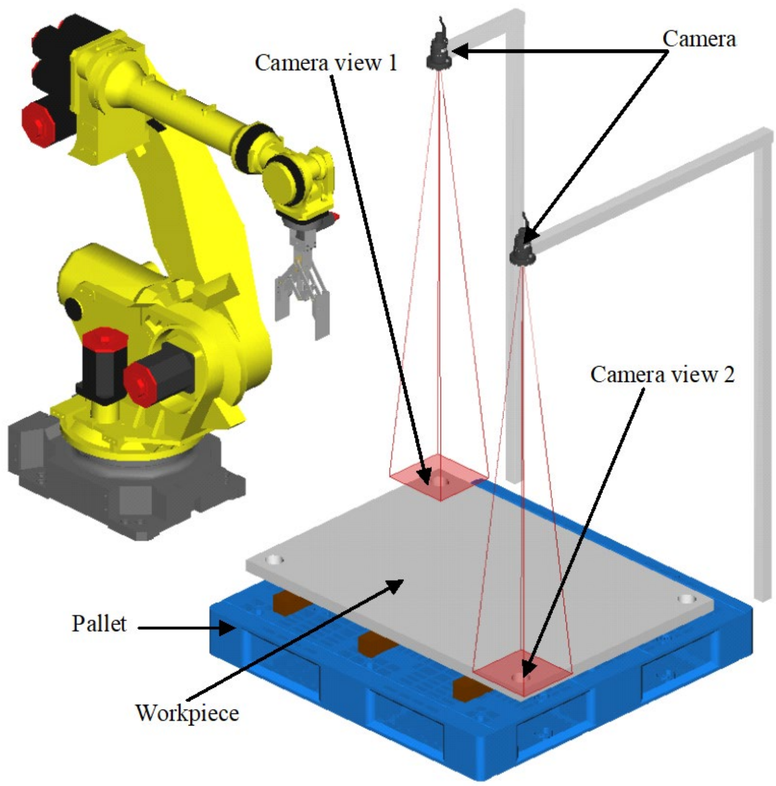
The 2D Multi-view Vision Process measures the multiple points of a workpiece and offsets the robot with the two-dimensional. This function is used for the measurement of the large workpiece which cannot be fit in the field of view of a single camera. This chapter describes the setup procedure for 2D Multi-view Vision Process by using the following three application examples:

- Fixed frame offset with fixed camera
- Fixed frame offset with robot-mounted camera
- Tool offset with fixed camera

The basic setting procedures are the same as the 2D Single-view Vision Process. The 2D Multi-view Vision Process uses the 'camera views'. Only in this regard, the 2D Multi-view Vision Process differs from the 2D Single-view Vision Process.

Fixed frame offset with fixed camera

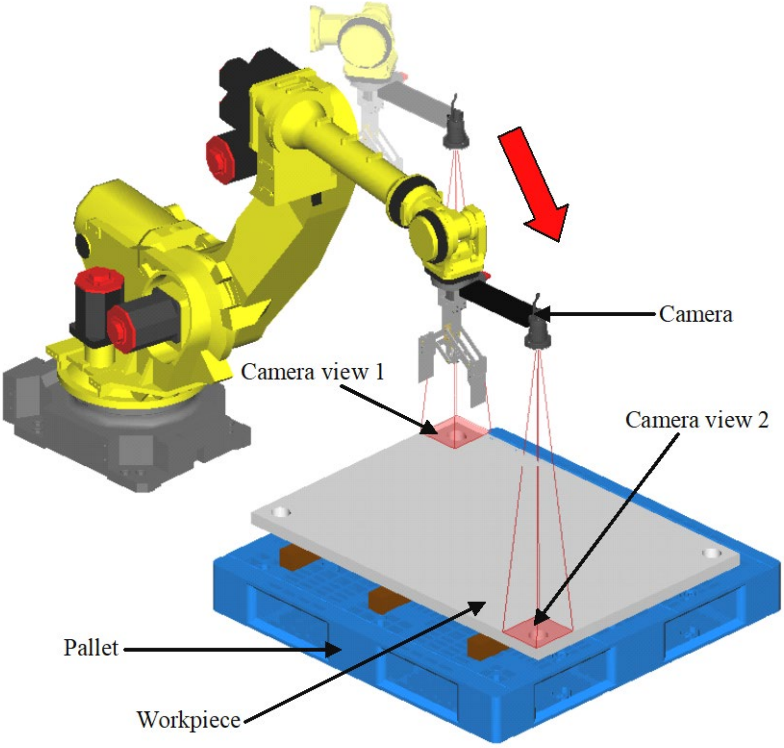
An example of layout for 'fixed frame offset with fixed camera' is shown below. A robot detects two measurement points of a workpiece with two cameras, and performs the Fixed frame offset.



Example of a layout for a fixed frame offset with a fixed camera

Fixed frame offset with robot-mounted camera

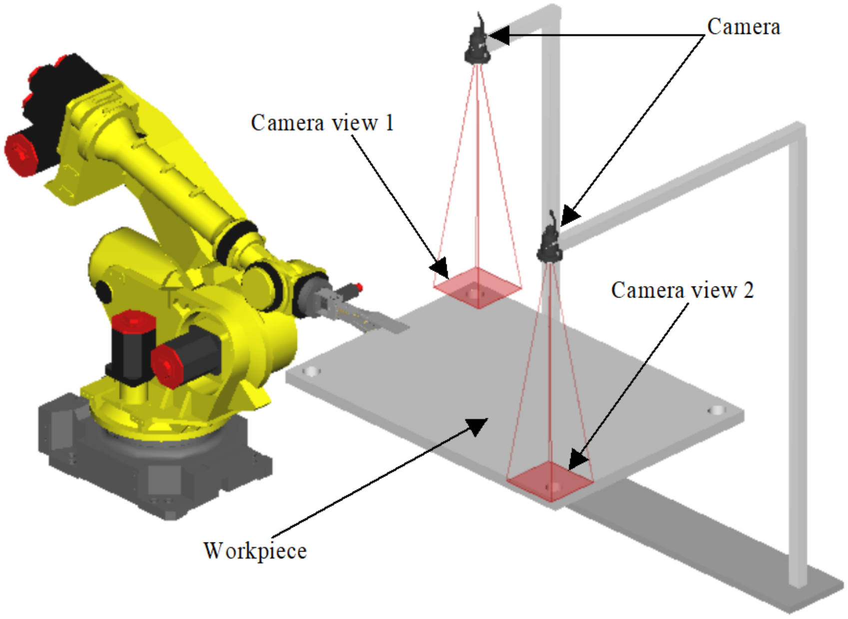
An example of layout for 'fixed frame offset with robot-mounted camera' is shown below. A robot detects two measurement points of a workpiece with a robot mounted camera, and performs Fixed frame offset.



Example of a layout for a fixed frame offset with a robot-mounted camera

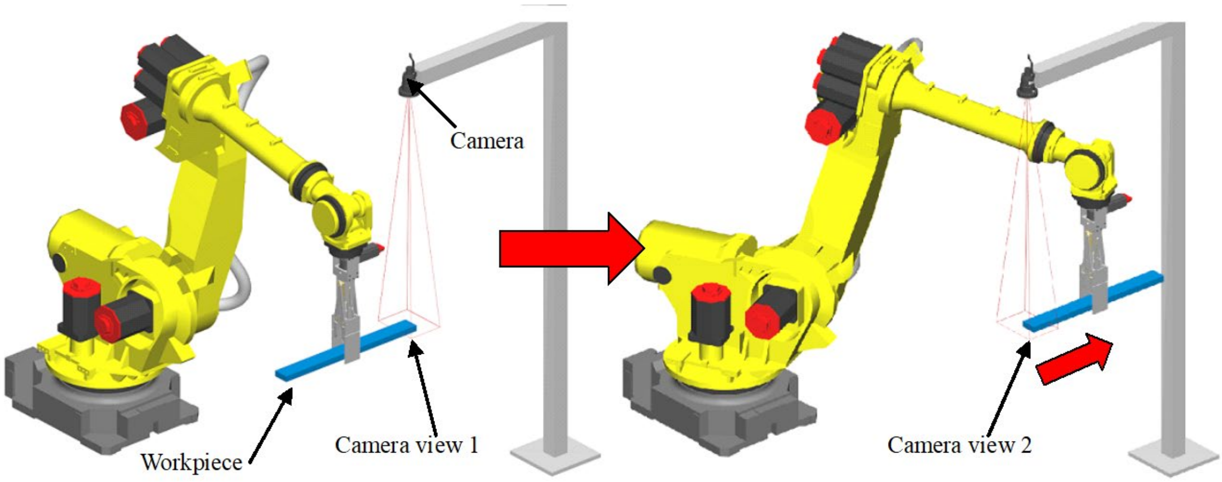
Tool offset with fixed camera

An example of layout for 'tool offset with fixed camera' is shown below. A robot detects two measurement points of a workpiece with two cameras, and performs the Tool offset.



Example of a layout for a tool offset with two fixed cameras

The following figure is another example. A robot detects two measurement points of a workpiece with a single camera and performs the Tool offset.



Example of a layout for a tool offset with a fixed camera

2.1 FEATURES AND NOTES

Feature

- Measure the multiple measurement points of a large workpiece which cannot be fit in the field of view of a single camera, and offset the robot on the two-dimensional.
- Fixed frame offset and Tool offset are supported.
- Fixed camera and robot-mounted camera can be used.
- When a robot-mounted camera is used, the position of a workpiece can be measured even when the robot moves in the X and Y directions of the offset frame. This is because, *i*RVision calculates the positions of the workpiece based on the current position of the robot.

Notes

- The offset is applied to the XY and R directions. Therefore, each measurement plane should be parallel to the XY plane of the offset frame and should not be tilted.
- Up to the four measurement points (four camera views) can be set.
- Even when a fixed camera or a robot-mounted camera is used, the optical axis of the camera should be vertical to the XY plane of the offset frame. When the position of the camera is tilted against the measurement points of the workpiece, the shape of the workpiece in the image may change depending on the location of the workpiece, so the detection may become difficult.

2.2 SETUP FOR FIXED FRAME OFFSET WITH FIXED CAMERA

The setup procedures for the fixed frame offset with the fixed camera is shown below:

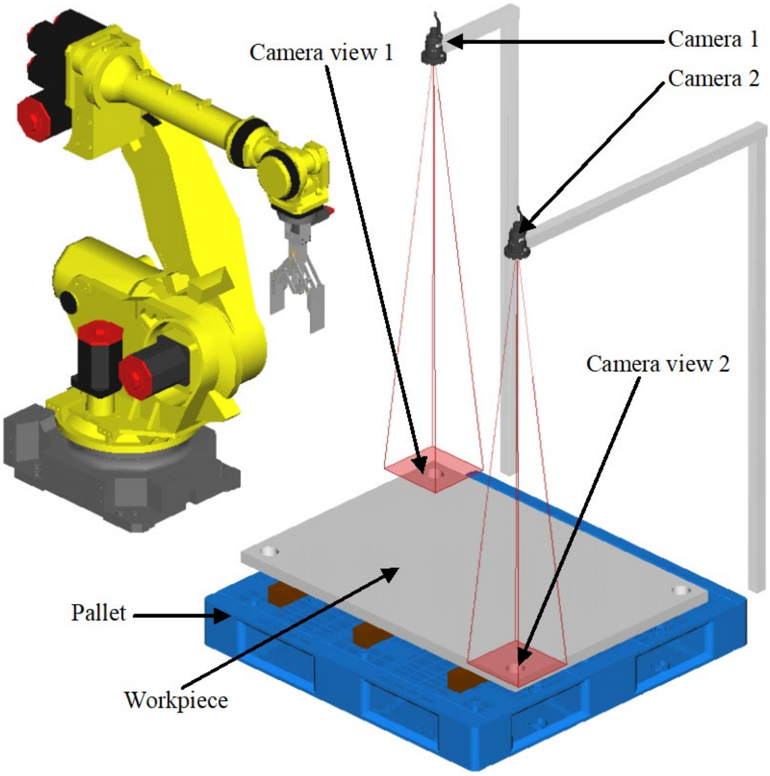
1. Camera Data Creation and Teaching
2. Offset frame setting
3. Vision process creation and teaching
4. Robot program creation and teaching
5. Robot Compensation Operation Check

When create the vision system newly, perform all of the above procedures. When the position of the installed camera is changed or the cameras are exchanged, redo the camera calibration in '1 Camera Data Creation and Teaching'. When you need to add a new kind of workpiece, if a camera calibration has been already done, the re-calibration of the camera is not needed. Perform '3 Vision process creation and teaching' and '4 Robot program creation and teaching'.

2.2.1 Camera Data Creation and Teaching

Create a camera data and perform the basic settings and the calibration for the camera.

In the 2-D Multi-View Vision Process, the camera calibrations are required for each camera. Create the camera data as many as the number of camera units. As an example, two camera data should be taught in the below figure.

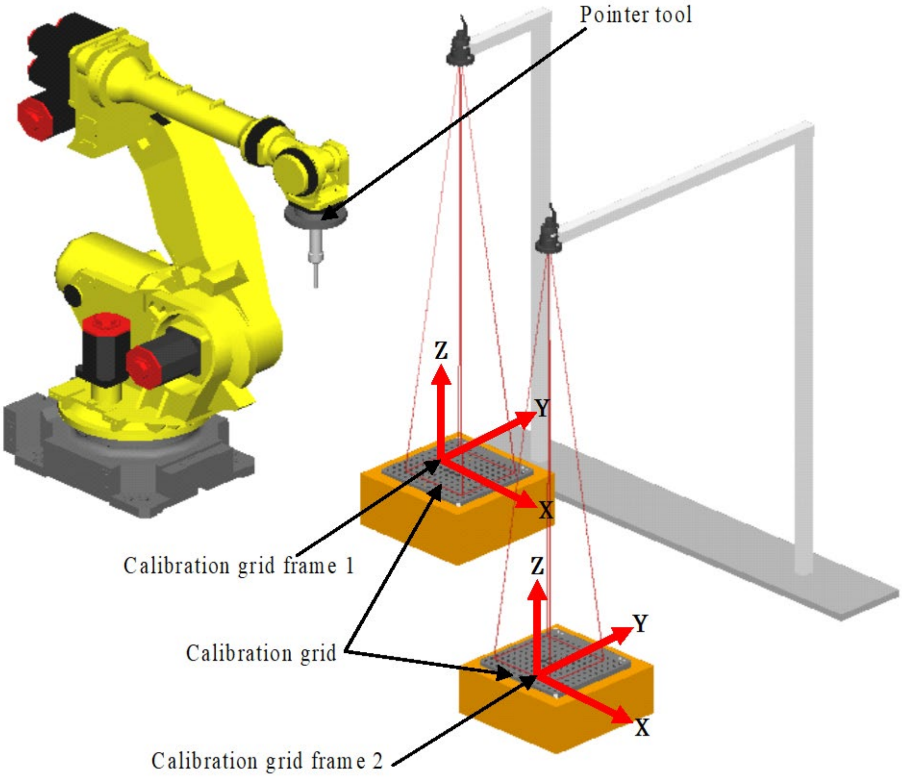


Example of a layout for creating camera data for each camera

The Grid Pattern Calibration and the Robot-generated Grid Calibration can be used to calibrate a fixed camera.

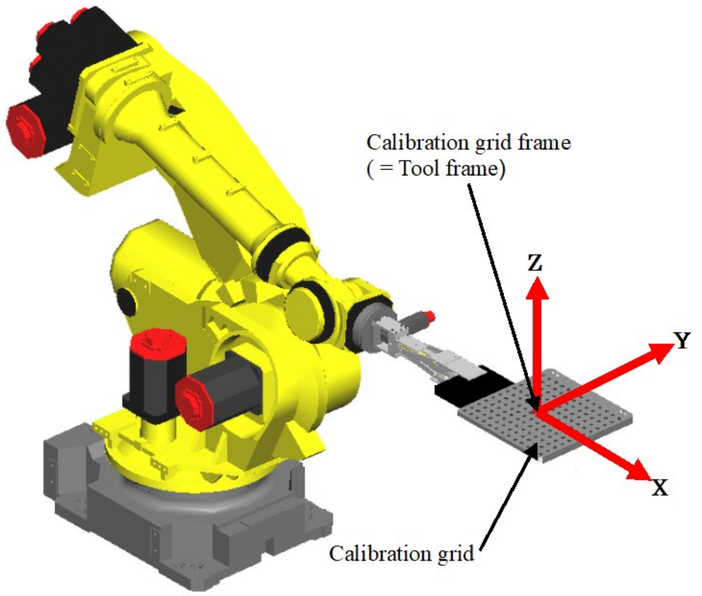
Grid Pattern Calibration

When the calibration grids are installed on the table, set the calibration grid frames of each camera and perform the calibration as the following figure.



Installation example for Grid Pattern Calibration

As the following figure, a calibration can also be performed with the installed calibration grid on the robot. In this case, the calibration can be performed with only the one calibration grid frame. When set the calibration grid information, the grid frame setting is recommended.



Installation example for a calibration grid attached to the robot's wrist

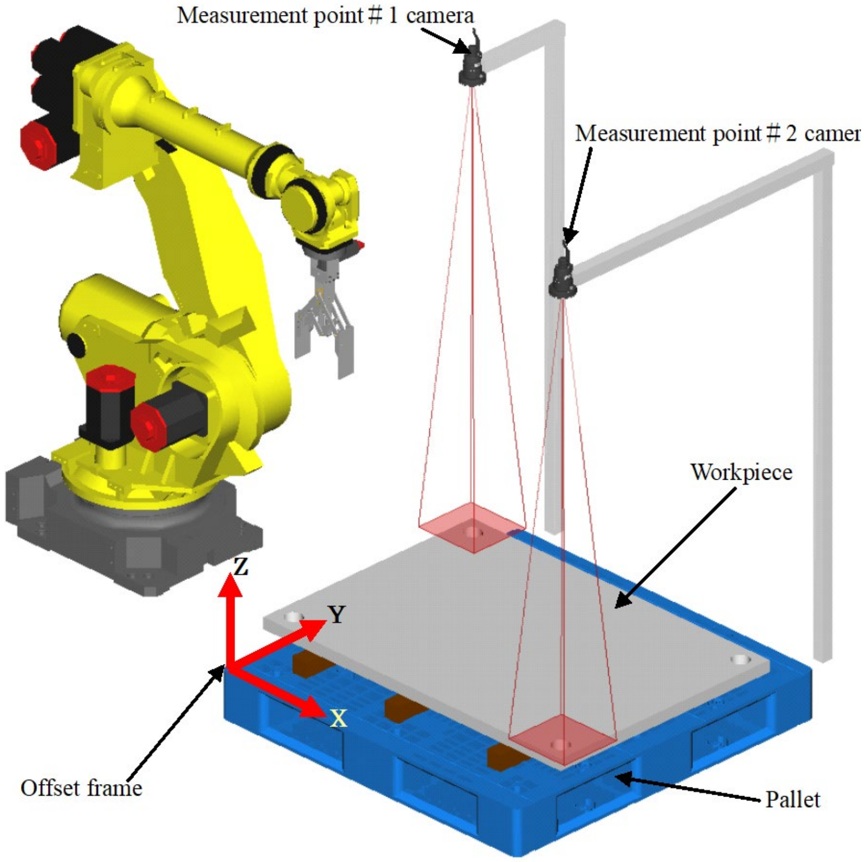
For details of the grid frame calibration, refer to Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA".

Robot-Generated Grid Calibration

When the Robot-generated Grid Calibration is used, the camera calibration for each camera can be performed with a target. For details of the Robot-generated Grid Calibration, refer to Know-how Edition Section 2.3, “ROBOT-GENERATED GRID CALIBRATION”.

2.2.2 Offset Frame Setting

The offset frame is used for the calculation of the offset data. The position of a found workpiece is outputted as the position on the offset frame. In the fixed frame offset, the offset frame is set as a user frame. Set an offset frame so that the XY plane of the offset frame is parallel with the table plane where the workpiece is placed. When the offset frame is not parallel with the plane where the workpiece is placed, the accuracy of offset may become low.
In the 2-D Multi-View Vision Process, the camera data are created as many as the number of camera units, but only one offset frame is required.



Offset frame setting

‘Touch-up with the pointer tool’ and ‘Automatic Grid Frame Setting Function’ can be used to set the offset frame.

Touch-up

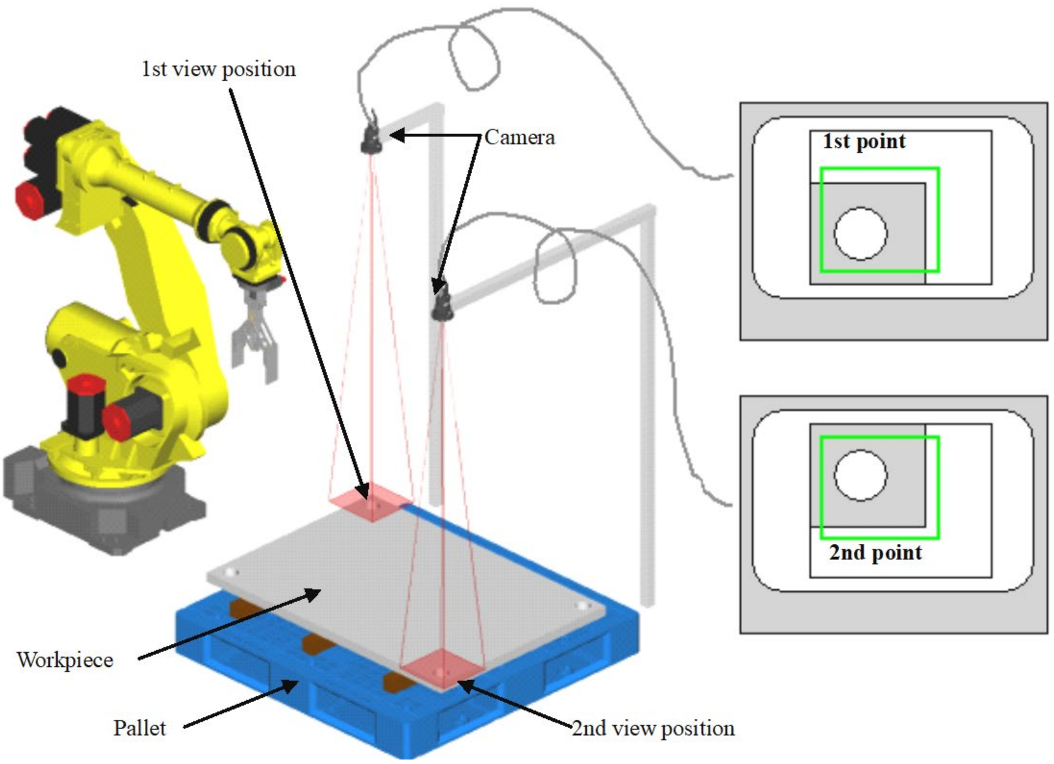
When set the user frame by touch-up method, a pointer tool with TCP is needed. In general, attach the pointer tool to the robot hand and set the TCP accurately at the tip of the pointer tool. If the accuracy of TCP setting is low, the accuracy of the offset is also degraded. Set a TCP in an arbitrary tool frame. When you reuse the pointer tool later, install the pointer tool in where the same location as when the TCP setting had performed. If the reproducibility of pointer installation is not assured, a TCP setting needs again. For details, refer to Know-how Edition Subsection 1.1.1, "User Frame Setting".

Grid Frame Setting Function

The Grid Frame Setting Function sets the user frame on the calibration grid frame by using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane where the workpiece is placed, and perform the Grid Frame Setting Function. For details, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION". When a fixed camera is used, prepare another temporary camera to perform the Grid Frame Setting Function. The Grid Frame Setting Function can be only used with the 6-axis robot. This function cannot be used with the 4-axis robot and the 5-axis robot. When the 4-axis robot or the 5-axis robot is used, use the touch-up method.

2.2.3 Vision Process Creation and Teaching

Create a vision process and teach it.
The basic setting procedures are the same as the 2D Single-view Vision Process. The 2D Multi-view Vision Process uses the 'camera views'. Only in this regard, the 2D Multi-view Vision Process differs from the 2D Single-view Vision Process. For each measurement point, a camera view is named [camera view 1] or [camera view 2]. The snap tool and the locator tool such as the GPM Locator Tool are added under each camera view.



Vision process creation and teaching

The setup procedures for the 2D Multi-view Vision Process is shown below:

1. Teach locator tool for [Camera View 1].

⇩

2. Teach locator tool for [Camera View 2].

⇩

3 Select [Camera View 1] and click [SNAP] to snap an image, and click [FIND] to detect a workpiece.

⇩

4. Select [Camera View 2] and click [SNAP] to snap an image, and click [FIND] to detect a workpiece.

⇩

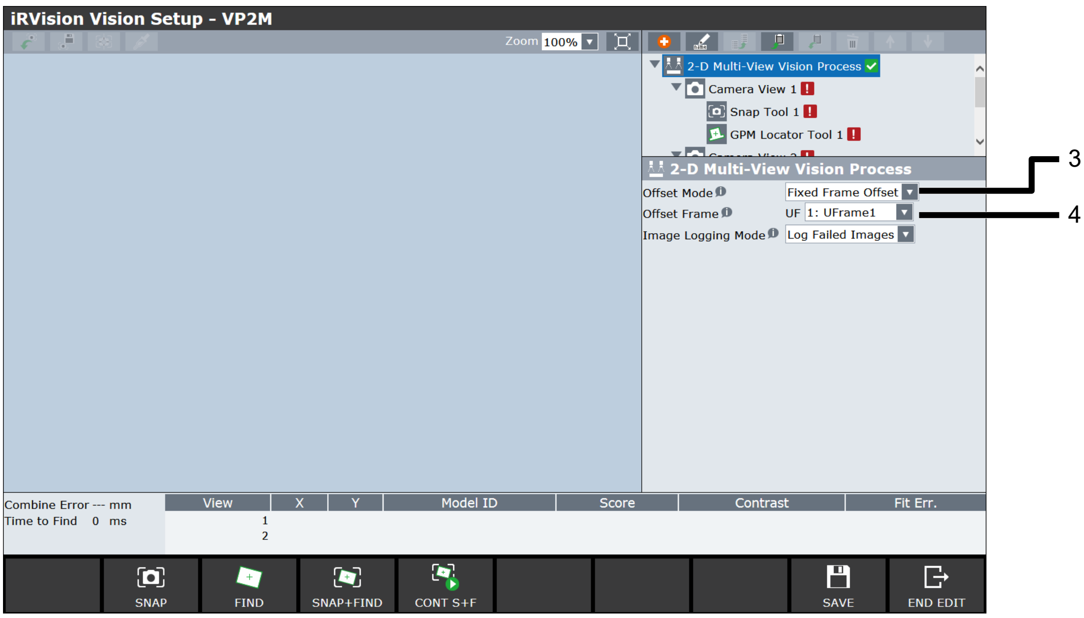
5. Select [2D Multi-View Vision Process] then set a reference position.

Set the reference position without moving the workpiece after snapping the images of the workpiece by two camera views. Note that the snapped images will be cleared if the vision setup screen is closed. If reopened the vision setup screen, snap again the workpiece by the two camera views before trying to set the reference position again.

2.2.3.1 Vision process creation

1 Create a vision process for [2-D Multi-View Vision Process].
For details of a vision process creation, refer to the description of creating new vision data in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, when a created vision process is selected and clicked [Edit], the vision data edit screen will appear.



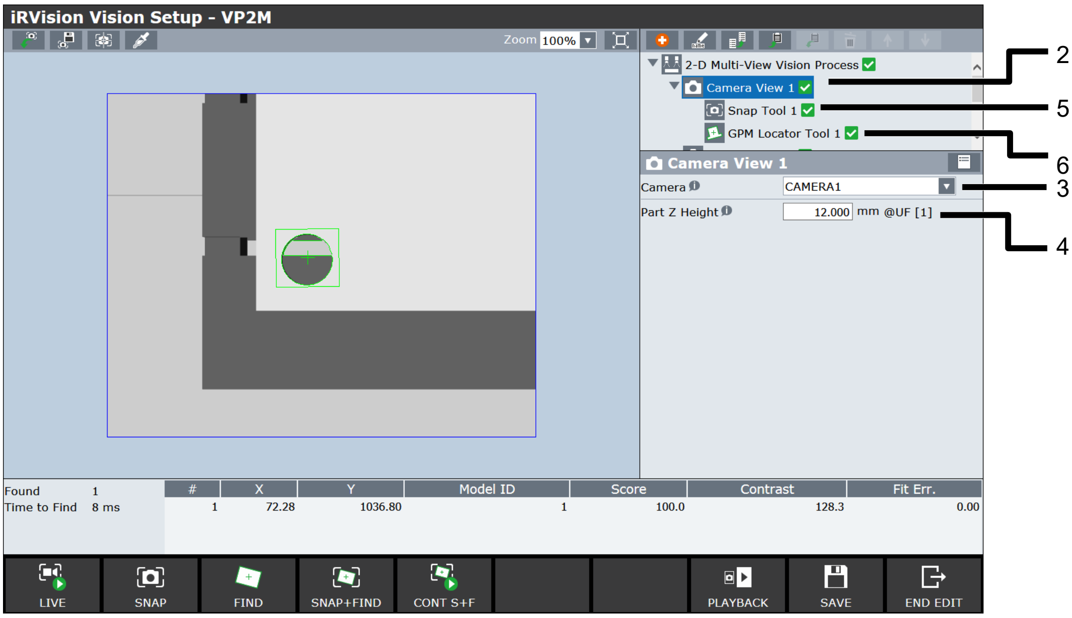
3 From the [Offset Mode] drop-down box, select [Fixed Frame Offset].

4 From the [Offset Frame] drop-down box, select the user frame to set.
Select the frame number specified in Setup Edition Subsection 2.2.2, "Offset Frame Setting".

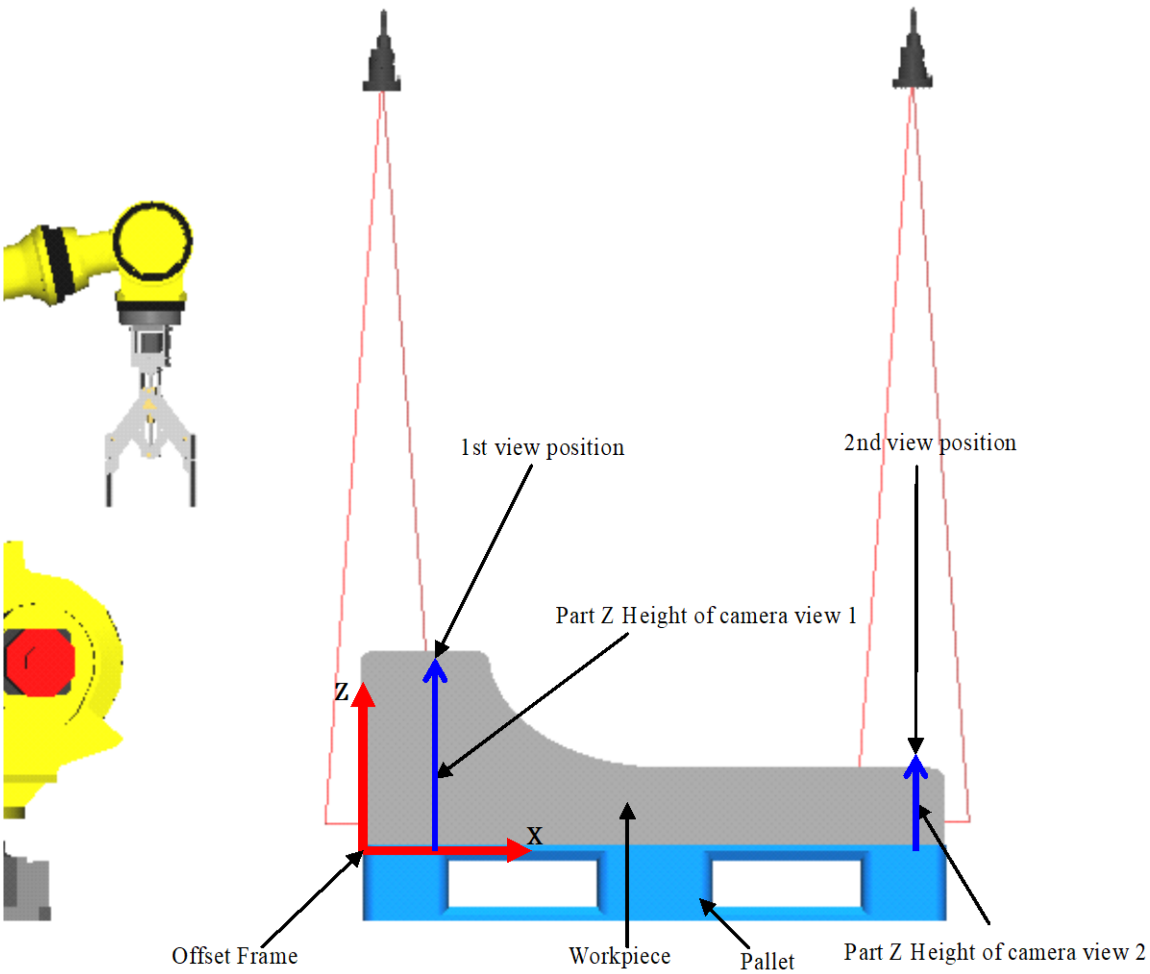
2.2.3.2 Camera view teaching

Teach the snap tool and the locator tool such as GPM Locator Tool, for each camera view.

1 Place a workpiece in the field of view of the camera.
2 Select [Camera View 1] from the tree view.



3 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 2.2.1, "Camera Data Creation and Teaching".
4 In the text box for [Part Z Height], enter the height of the detected part of the workpiece.
When the XY plane of the offset frame is apart from the detected part of the workpiece, enter the distance.
Enter an appropriate value for each camera view as shown in the figure below.



Offset Frame and Part Z Height

5 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap window and the exposure time. For details, refer to the description of Snap Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

6 Select a locator tool from the tree view and teach the model used in detection.
By default, the GPM Locator Tool is set as the locator tool. For details of the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

7 Click [SNAP] to snap an image.

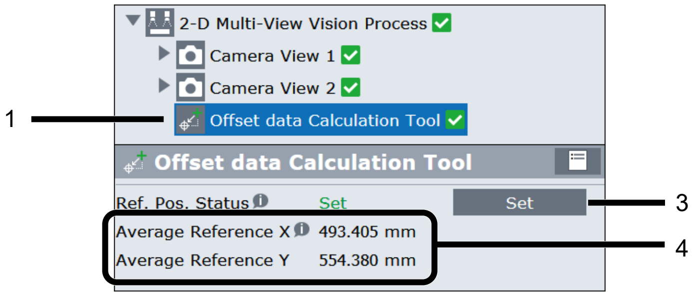
8 After [Camera View 1] setup is completed, repeat the steps from 2 to 7 for another camera view in the same way.

> **Memo**
> To add a camera view, select the vision process in the tree view and click the button.

2.2.3.3 Setting the reference position

1 Select [Offset data Calculation Tool] in the tree view.
2 Click [FIND] to find the workpiece for all camera views.

> ⚠ **CAUTION**
> Do not move the workpiece until the reference position setting is complete.



3 Click the [Set] button for [Ref. Pos. Status]
4 Check that [Ref. Pos. Status] becomes [Set] and the values for [Average Reference X] and [Average Reference Y] is displayed.
The values are the position of the center of gravity of the workpiece on the offset frame.
5 Click [Save] and click [End Edit].
6 Move the robot to the position to work to the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 2.2.4, "Robot Program Creation and Teaching". P[2] in line 11 is the position to work to the workpiece. Record the current robot position on P[2], and the reference position setting is complete.

2.2.4 Robot Program Creation and Teaching

The sample program is shown below. A vision process [A] is used. Two measurement points of a large workpiece are detected. When the fixed cameras are used, it is not necessary to specify the camera view number to the [VISION RUN_FIND] instruction. Add the "VOFFSET, VR" instruction to the movement statement.

```
 1:     UFRAME_NUM=1 ;
 2:     UTOOL_NUM=1 ;
 3:     R[1:Notfound]=0      ;
 4:L P[1] 2000mm/sec FINE      ;
 5:      ;
 6:     VISION RUN_FIND 'A'      ;
 7:     VISION GET_OFFSET 'A' VR[1] JMP LBL[100] ;
 8:      ;
 9:     !Handling ;
10:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]      ;
11:L P[2] 500mm/sec FINE VOFFSET,VR[1]      ;
12:     CALL HAND_CLOSE      ;
13:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]      ;
14:     !Handling ;
15:     JMP_LBL[900] ;
16:     ;
17:     LBL[100] ;
18:     R[1:Notfound]=1      ;
19:      ;
20:     LBL[900] ;
```

Detect the workpiece on line 6. Obtain the offset data on line 7. Move the robot to the approach position above the workpiece on line 10. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Line 11 is the picking position. Move the robot to the escape position after grasping the workpiece on line 13. When a fixed camera is used, the measurement of all camera views can be executed by calling once the [VISION RUN_FIND] instruction. After the images of all camera views have been snapped, the line after the [VISION RUN_FIND] instruction is executed.

2.2.5 Robot Compensation Operation Check

Check that multiple points of a workpiece can be detected and that the workpiece can be handled accuracy.

- Place the workpiece on the reference position. Find it and check the handling accuracy. If the accuracy of the offset is low, set the reference position again.
- Move the workpiece without rotation, find it and check the handling accuracy. If the offset accuracy is good on the reference position but it lows on the edge of the field of view, it is possible that Part Z Height is not set properly. Refer to Setup Edition Subsection 2.2.3.2, "Camera view teaching" and make sure that [Part Z Height] is correctly set for the workpiece.
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy of the offset is good on the non-rotated workpiece but it lows on rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. When set the frames using the touch-up method with a pointer tool, check the TCP setting is precise. Moreover, check the offset frame and calibration grid frame are set precisely. If there is necessary, retry the camera calibration.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

Memo

If the workpiece cannot be found correctly due to a variation in the distances between measurement points, e.g., due to individual difference of workpieces, switch to the advanced mode in [Offset data Calculation Tool] and set [Combine Error Limit].

2.3 SETUP FOR FIXED FRAME OFFSET WITH ROBOT-MOUNTED CAMERA

The setup procedures for the fixed frame offset with the robot-mounted camera is shown below:

1. Camera Data Creation and Teaching

⇩

2. Offset frame setting

⇩

3. Vision process creation and teaching

⇩

4. Robot program creation and teaching

⇩

5. Robot Compensation Operation Check

When create the vision system newly, perform all of the above procedures. When the position of the camera on the robot mechanical interface (the robot face plane) is changed or the cameras are exchanged, redo the camera calibration in '1 Camera Data Creation and Teaching'. When you need to add a new kind of workpiece, if a camera calibration has been already done, the re-calibration of the camera is not needed. Perform '3 Vision process creation and teaching' and '4 Robot program creation and teaching'.

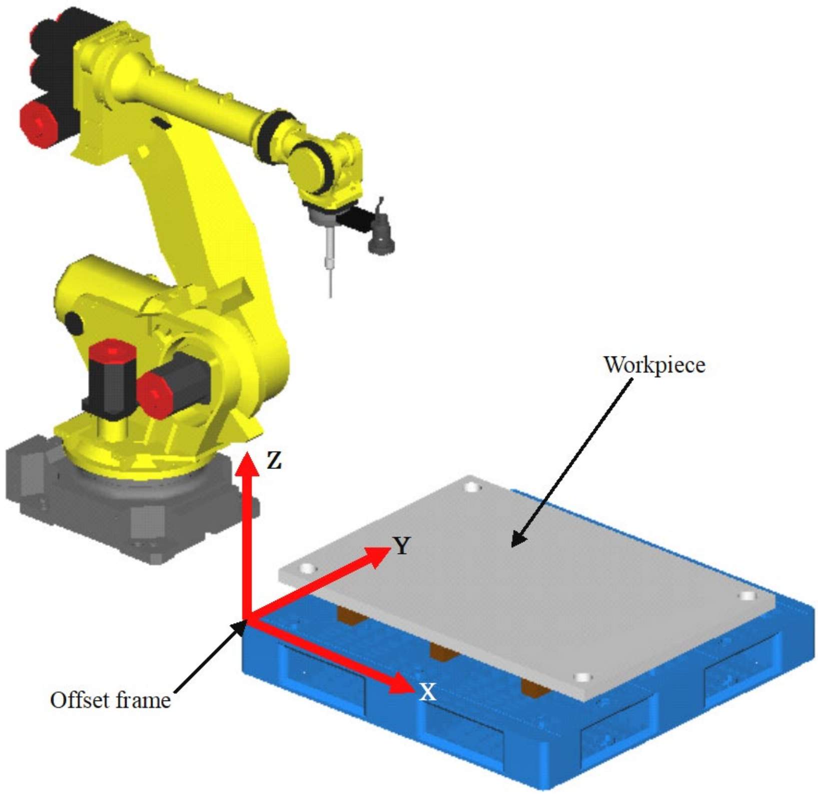
2.3.1 Camera Data Creation and Teaching

Create a camera data and perform basic settings and calibration for the camera.

When the 2D Multi-view Vision Process is performed with a robot-mounted camera, measure the multiple points on a workpiece by one camera. So, teach just one camera data. When using a robot-mounted camera, perform the Grid Pattern Calibration. In the case of a robot-mounted camera, the Robot-generated Grid Calibration cannot be used. For details of the grid frame calibration, refer to Know-how Edition Section 2.2, "GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA".

2.3.2 Offset Frame Setting

The offset frame is used for the calculation of the offset data. The position of a found workpiece is outputted as the position on the offset frame. In the fixed frame offset, the offset frame is set as a user frame.
Set an offset frame so that the XY plane of the offset frame is parallel with the table plane where the workpiece is placed. When the offset frame is not parallel with the plane where the workpiece is placed, the accuracy of offset may become low.



Offset frame setting

There are two methods to teach the offset frame, one is touch-up with the pointer tool, and another is the Automatic Grid Frame Setting Function.

Touch-up

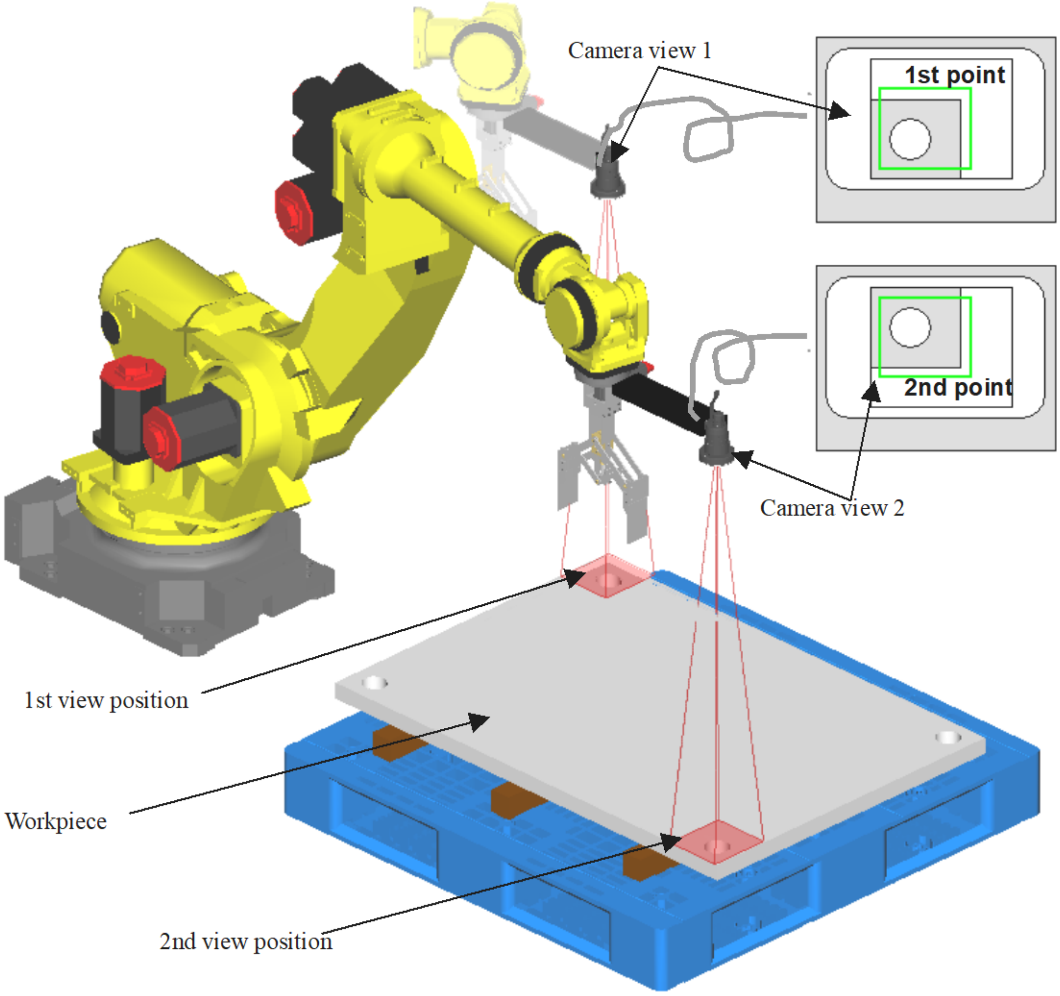
When set the user frame by touch-up method, a pointer tool with TCP is needed. In general, attach the pointer tool to the robot hand and set the TCP accurately at the tip of the pointer tool. If the accuracy of TCP setting is low, the accuracy of the offset is also degraded. Set a TCP in an arbitrary tool frame. When you reuse the pointer tool later, install the pointer tool in where the same location as when the TCP setting had performed. If the reproducibility of pointer installation is not assured, a TCP setting needs again. For details, refer to Know-how Edition Subsection 1.1.1, "User Frame Setting".

Grid Frame Setting Function

The Grid Frame Setting Function sets the user frame on the calibration grid frame by using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane where the workpiece is placed, and perform the Grid Frame Setting Function. For details, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION". When a robot-mounted camera is used, the camera can be used for the Grid Frame Setting Function. When there is not sufficient space to perform the Grid Frame Setting Function with the camera, prepare another temporary robot-mounted camera and perform the Grid Frame Setting Function. The Grid Frame Setting Function can be only used with the 6-axis robot. This function cannot be used with the 4-axis robot and the 5-axis robot. When the 4-axis robot or the 5-axis robot is used, use the touch-up method.

2.3.3 Vision Process Creation and Teaching

Create a vision process and teach it.
The basic setting procedures are the same as the 2D Single-view Vision Process. The 2D Multi-view Vision Process uses the 'camera views'. Only in this regard, the 2D Multi-view Vision Process differs from the 2D Single-view Vision Process. For each measurement point, a camera view is named [camera view 1] or [camera view 2]. The snap tool and the locator tool such as the GPM Locator Tool are added under each camera view.



Vision process creation and teaching

The setup procedures for the 2D Multi-view Vision Process is shown below:

1. Move the robot to the first measurement position, and teach the locator tool for [Camera View 1].

⇩

2. Select [Camera View 1] and click [SNAP] to snap an image of the workpiece.

⇩

3. Move the robot to the second measurement position, and teach the locator tool for [Camera View 2].

⇩

4. Select [Camera View 2] and click [SNAP] to snap an image of the workpiece.

⇩

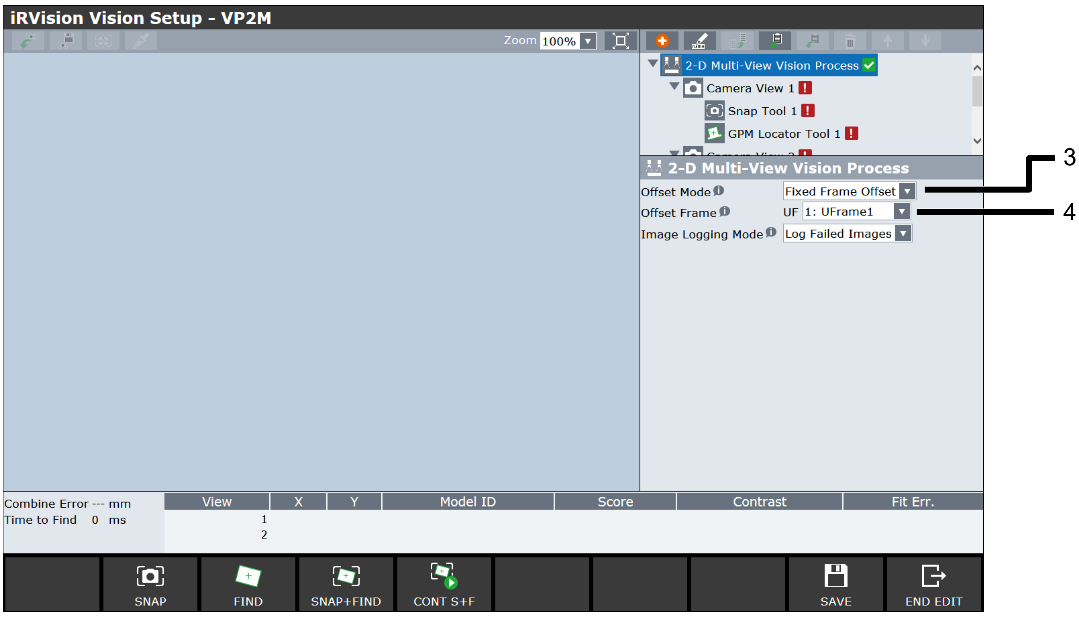
5 Select [Offset data Calculation Tool] and set a reference position.

Set the reference position without moving the workpiece after snapping the images of the workpiece by two camera views. Note that the snapped images will be cleared if the vision setup screen is closed. If reopened the vision setup screen, snap again the workpiece by the two camera views before trying to set the reference position again.

2.3.3.1 Vision process creation

1 Create a vision process for [2-D Multi-View Vision Process].
For details of the vision process creation, refer to the description of creating new vision data in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, when a created vision process is selected and clicked [Edit], the vision data edit screen will appear.



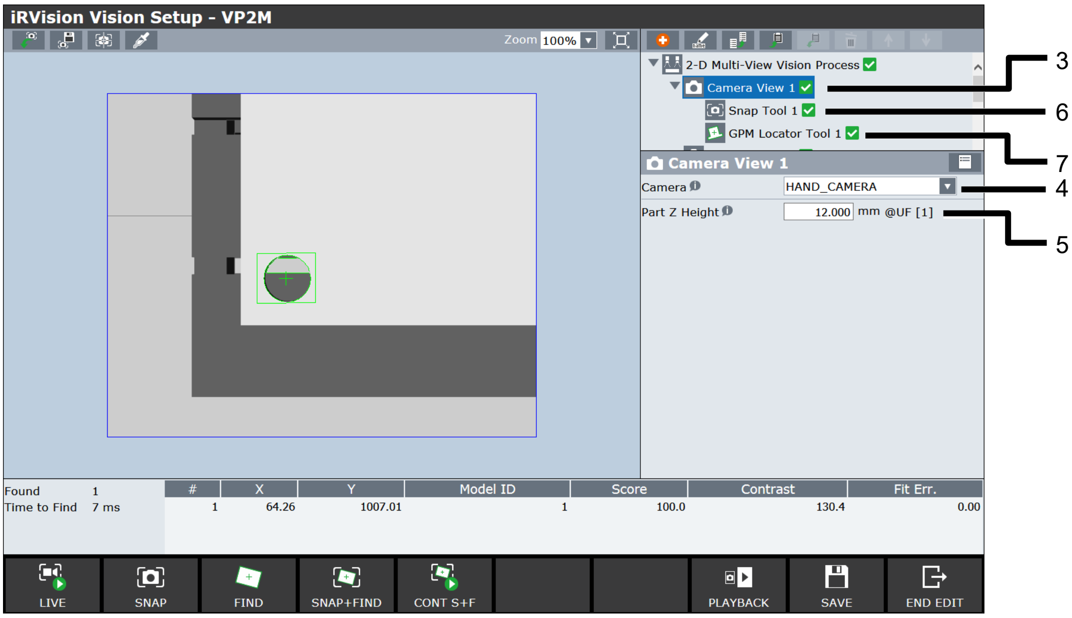
3 From the [Offset Mode] drop-down box, select [Fixed Frame Offset].

4 From the [Offset Frame] drop-down box, select the user frame to set.
Select the frame number specified in Setup Edition Subsection 2.3.2, "Offset Frame Setting".

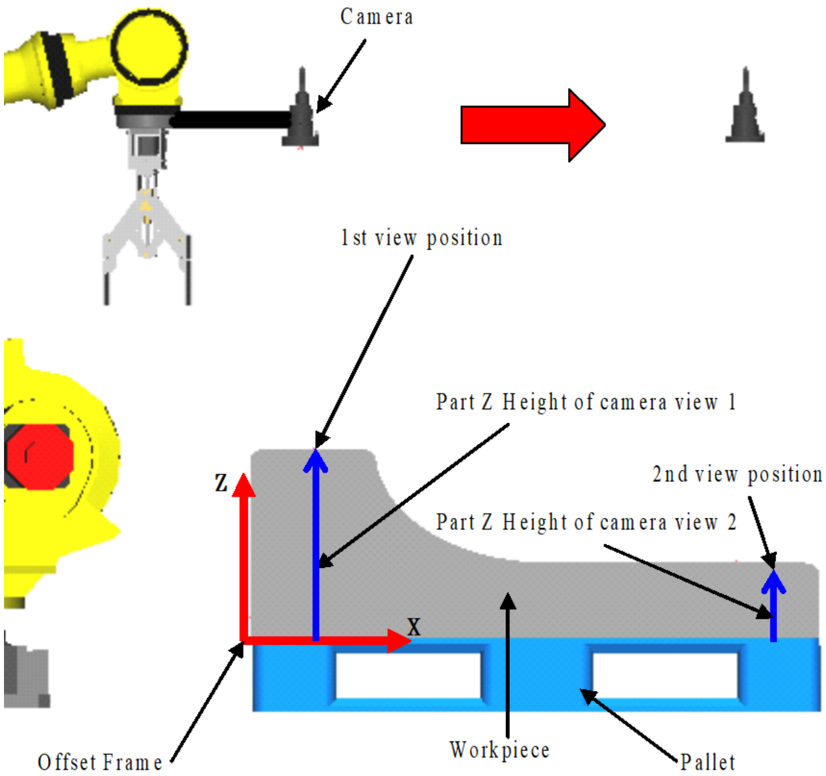
2.3.3.2 Camera view teaching

Teach the snap tool and the locator tool such as GPM Locator Tool, for each camera view.

1 Place a workpiece in the field of view of the camera.
2 Move the robot to the measurement position where the workpiece can be snapped.
Record this robot position as the first measurement position. Refer to the sample program in Setup Edition Subsection 2.3.4, "Robot Program Creation and Teaching". P[1] in line 4 is the first measurement position. Record the current robot position to P[1].
3 Select [Camera View 1] from the tree view.



4 From the [Camera] drop-down box, select the camera data to be used
Select the camera data specified in Setup Edition Subsection 2.3.1, "Camera Data Creation and Teaching".
5 Enter the height of the measurement plane of workpiece in the text box in [Part Z Height].
If there is a distance between the XY plane of the offset frame and the measurement plane of the workpiece, enter the value.
Set an appropriate value for each camera view as shown in the figure below.



Offset Frame and Part Z Height

6 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap window and the exposure time. For details, refer to the description of Snap Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

7 Select a locator tool from the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details of the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

8 Click [SNAP] to snap an image.

9 After [Camera View 1] setup is completed, repeat the steps from 2 to 8 for another camera view in the same way.

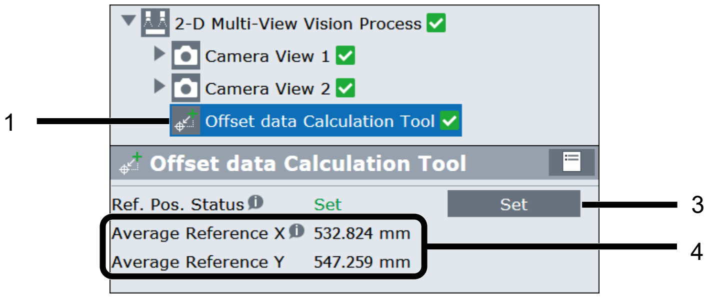
> **Memo**
> When you add a camera view, select the vision process from the tree view and click the button.

2.3.3.3 Reference position setting

1 Select [Offset data Calculation Tool] in the tree view.

> ⚠ **CAUTION**
> Regarding the following steps, do not click [SNAP] on the offset data calculation tool until the reference position setting is completed. Otherwise, images are snapped at the current position for all camera views and prevent you from setting the reference position. Also, do not move the workpiece.

2 Click [FIND] to find the workpiece for all camera views.



3 Click the [Set] button for [Ref. Pos. Status]

4 Check that [Ref. Pos. Status] becomes [Set] and the values for [Average Reference X] and [Average Reference Y] is displayed.
The values are the position of the center of gravity of the workpiece on the offset frame.

5 Click [Save] and click [End Edit].

6 Move the robot to the position to work to the workpiece (e.g. gripping it).
Refer to the sample program in Setup Edition Subsection 2.3.4, "Robot Program Creation and Teaching". P[3] in line 14 is the position to work to the workpiece. Record the current robot position on P[3], and the reference position setting is completed.

2.3.4 Robot Program Creation and Teaching

The sample program is shown below. A vision process [A] is used. Two measurement points of a large workpiece are detected while moving the robot-mounted camera. Program [A] has two camera views, so add the each camera view number to the [VISION RUN_FIND] instruction. Add the "VOFFSET, VR" instruction to the movement statement.

```
 1:    UFRAME_NUM=1 ;
 2:    UTOOL_NUM=1 ;
 3:    R[1:Notfound]=0     ;
 4:L P[1] 2000mm/sec FINE     ;
 5:    WAIT R[1] ;
 6:    VISION RUN_FIND 'A' CAMERA_VIEW[1]     ;
 7:L P[2] 2000mm/sec FINE     ;
 8:    WAIT R[1] ;
 9:    VISION RUN_FIND 'A' CAMERA_VIEW[2]     ;
10:    VISION GET_OFFSET 'A' VR[1] JMP LBL[100] ;
11:      ;
12:    !Handling ;
13:L P[3] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]     ;
14:L P[3] 500mm/sec FINE VOFFSET,VR[1]     ;
15:    CALL HAND_CLOSE     ;
16:L P[3] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]     ;
17:    !Handling ;
18:    JMP_LBL[900] ;
19:      ;
20:    LBL[100] ;
21:    R[1:Notfound]=1     ;
22:      ;
23:    LBL[900] ;
```

After the snap of the image is completed on the [VISION RUN_FIND] instruction, the next line is executed.
Move the robot to the snap position of camera view 1 on line 4. Execute “WAIT” instruction to remove the vibration of the camera on line 5. Execute the detection on the camera view 1 of program [A] by the vision detection instruction with on line 6. Move the robot to the position of camera view 2 to snap on line 7. Get the offset data of the detected workpiece on line 10. Move the robot to the approach position above the workpiece on line 13. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move the robot to grasp position on line 14. Move the robot to the escape position after grasping the workpiece on line 16.

2.3.5 Robot Compensation Operation Check

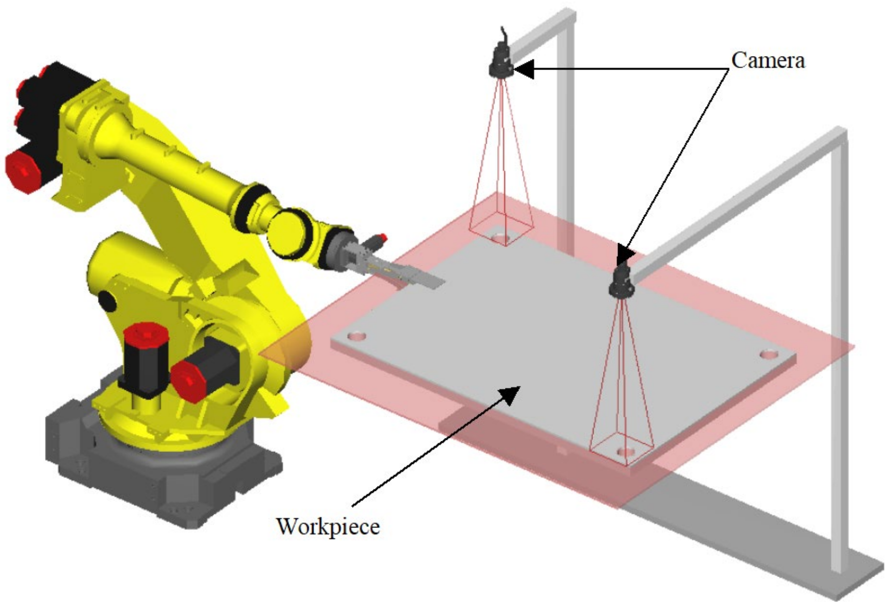
Check that the multiple points of a workpiece can be detected and that the workpiece can be handled accuracy.

- Place the workpiece on the reference position. Find it and check the handling accuracy. If the accuracy of offset is low, set the reference position again.
- Move the workpiece without rotation, find it and check the handling accuracy. If the offset accuracy is good on the reference position but it lows on the edge of the field of view, it is possible that [Part Z Height] is not set properly. Refer to Setup Edition Subsection 2.3.3.2, "Camera view teaching" and make sure that [Part Z Height] is correctly set for the workpiece.
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy of the offset is good on the non-rotated workpiece but it lows on rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. When set the frames using the touch-up method with a pointer tool, check the TCP setting is precise. Moreover, check the offset frame and calibration grid frame are set precisely. If there is necessary, retry the camera calibration.
- Depending on the robot motion, a camera may vibrate at snap position. Execute "WAIT" instruction to remove the vibration of a workpiece before the detection.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

> ✐**Memo**
> If the workpiece cannot be found correctly due to a variation in the distances between measurement points, e.g., due to individual difference of workpieces, switch to the advanced mode in [Offset data Calculation Tool] and set [Combine Error Limit].

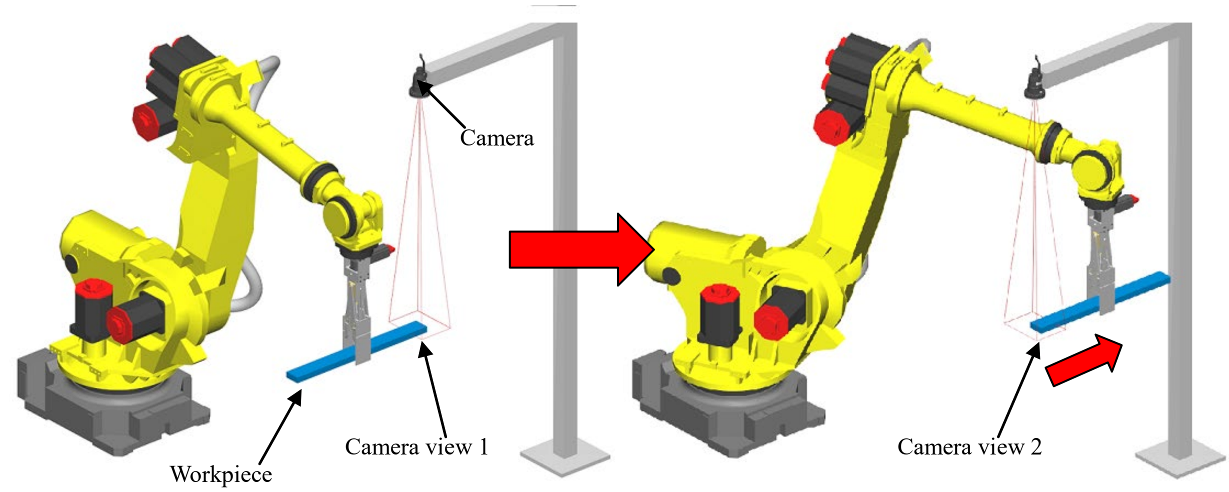
2.4 SETUP FOR TOOL OFFSET WITH FIXED CAMERA

An example of layout for 'tool offset with fixed camera' is shown below. A robot detects two measurement points of a workpiece with two cameras, and performs tool offset.



Example of a layout for a tool offset with two fixed cameras

The following figure is another example of a layout. A robot detects two measurement points of a workpiece with a camera, and performs tool offset. A robot grips a workpiece and detects a point of workpiece as the camera view 1. Next, the robot moves the workpiece and detects another point of workpiece as the camera view 2. In the configuration such as the following layout, only one camera data is needed. In other word, the same camera data is used in each camera view.



Example of a layout for a tool offset with a fixed camera

The setup procedures for the tool offset with the fixed camera is shown below:

1. Camera Data Creation and Teaching

⇩

2. Offset frame setting

⇩

3. Vision process creation and teaching

⇩

4. Robot program creation and teaching

⇩

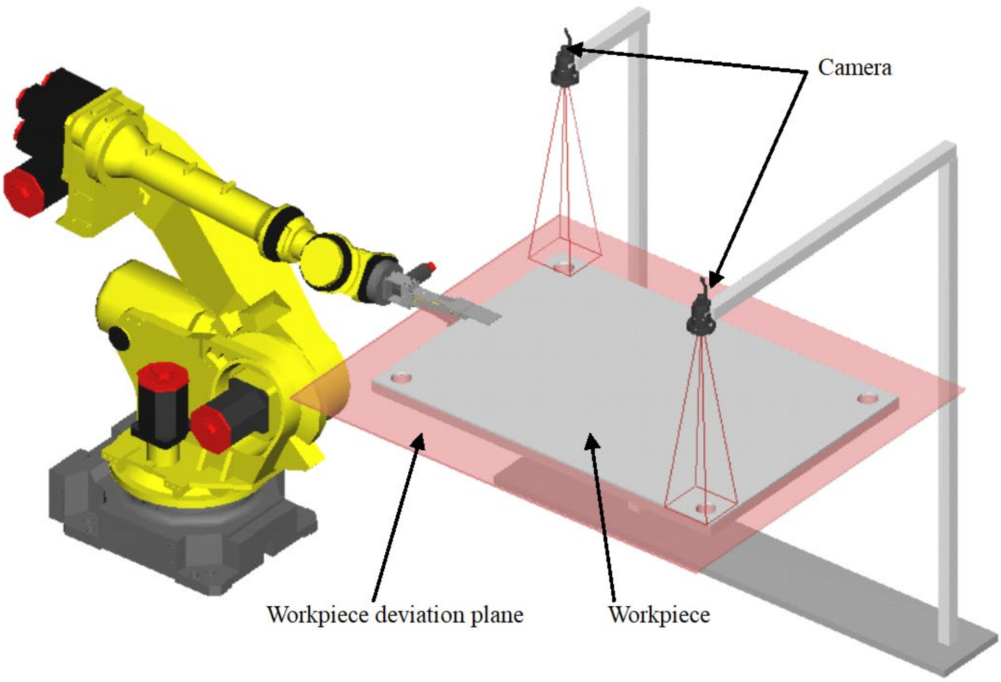
5. Robot Compensation Operation Check

When create the vision system newly, perform all of the above procedures. When the position of the installed camera is changed or the cameras are exchanged, redo the camera calibration in '1 Camera Data Creation and Teaching'. When you need to add a new kind of workpiece, if a camera calibration has been already done, the re-calibration of the camera is not needed. Perform '3 Vision process creation and teaching' and '4 Robot program creation and teaching'.

2.4.1 Camera Data Creation and Teaching

Create a camera data and perform basic settings and calibration for the camera.

In the 2-D Multi-View Vision Process, the camera calibrations are required for each camera. Create the camera data as many as the number of camera units. As an example, two camera data should be taught in the below figure.

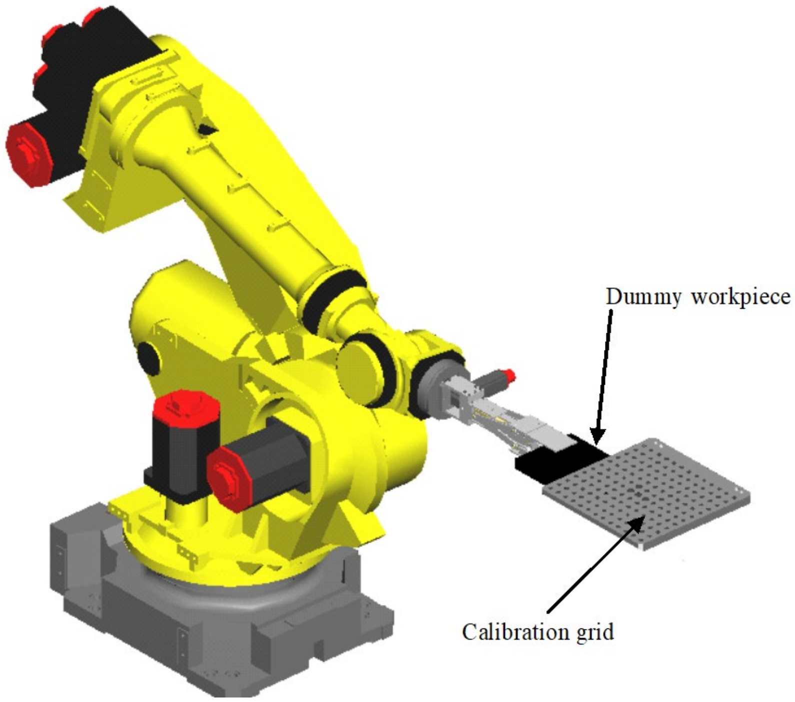


Example of a layout for creating camera data for each camera

The Grid Pattern Calibration and the Robot-generated Grid Calibration can be used to calibrate a fixed camera.

Grid Pattern Calibration

When the Grid Pattern Calibration is used for the calibration of tool offset, it is recommended to set the calibration grid on a dummy workpiece. In this case, the calibration can be performed with only the one calibration grid frame. When set the calibration grid information, the grid frame setting is recommended. In the following figures, the calibration grid is installed on the same position as the measurement position of workpiece. Prepare a dummy workpiece so that it can be gripped instead of an actual workpiece, and install the calibration grid on the dummy workpiece. By using this method, setup of the offset frame can be simplified. Install the calibration grid on the dummy workpiece so that the XY plane of the calibration grid is parallel with the plane where the workpiece moves.



Installation example for Grid Pattern Calibration

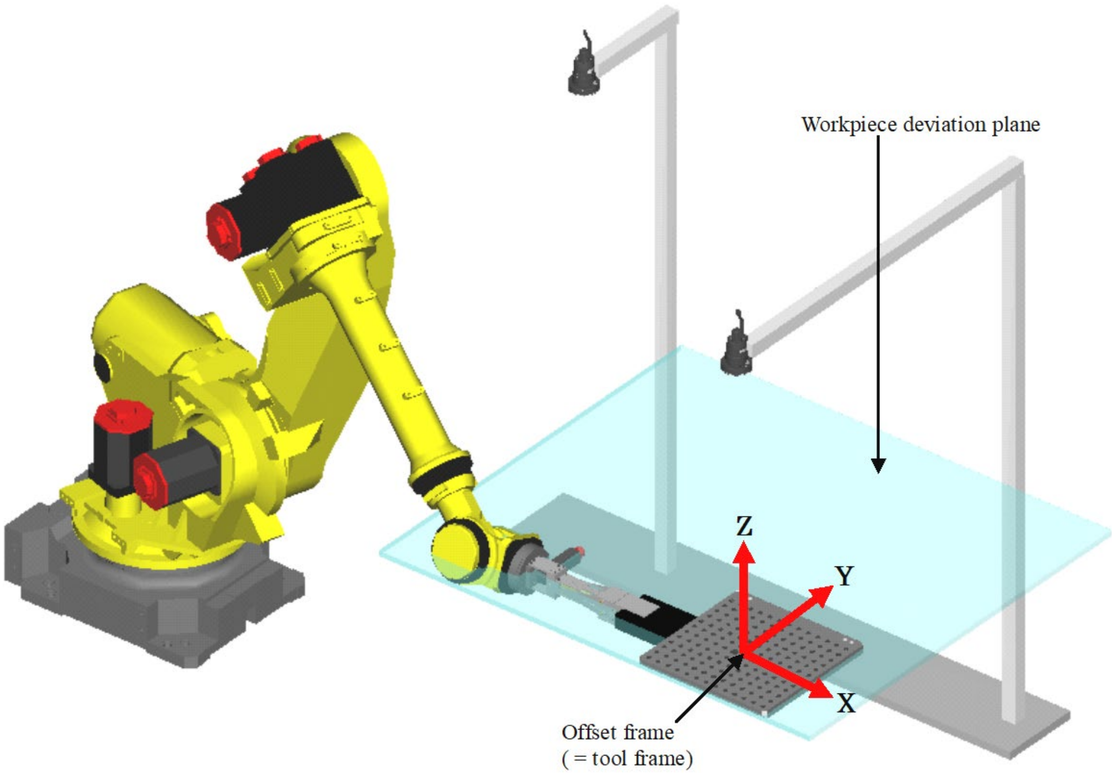
When install a calibration grid so that the XY plane of the calibration grid is parallel with the plane where a workpiece moves, a setup of the offset frame becomes easy. For details of the grid frame calibration, refer to Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA".

Robot-generated Grid Calibration

When the robot-generated grid calibration is used for the calibration of tool offset, it is recommended to attach a target mark to a dummy workpiece for calibration. Prepare a dummy workpiece so that it can be gripped instead of an actual workpiece, and install the target mark on the dummy workpiece. By using this method, setup of the offset frame can be simplified. Set a target mark so that the XY plane of the target mark is parallel with the plane on where a workpiece moves.
For details of the Robot-generated Grid Calibration, refer to Know-how Edition Section 2.3, "ROBOT-GENERATED GRID CALIBRATION".

2.4.2 Offset frame Setting

The offset frame is used for the calculation of the offset data. A found position is outputted as a position on the offset frame. In the fixed frame offset, the offset frame is set as a user frame, but in the tool offset, it is set as a tool frame. In the 2-D Multi-View Vision Process, the camera data are created as many as the number of camera units, but only one offset frame is required.
Set a tool frame so that the XY plane of the tool frame is parallel with the workpiece deviation plane.
When the Grid Pattern Calibration is used, if the XY plane of the tool frame that is set in Know-how Edition Subsection 2.1.4, "Calibration" is parallel with the workpiece deviation plane, the tool frame can be used as the offset frame.

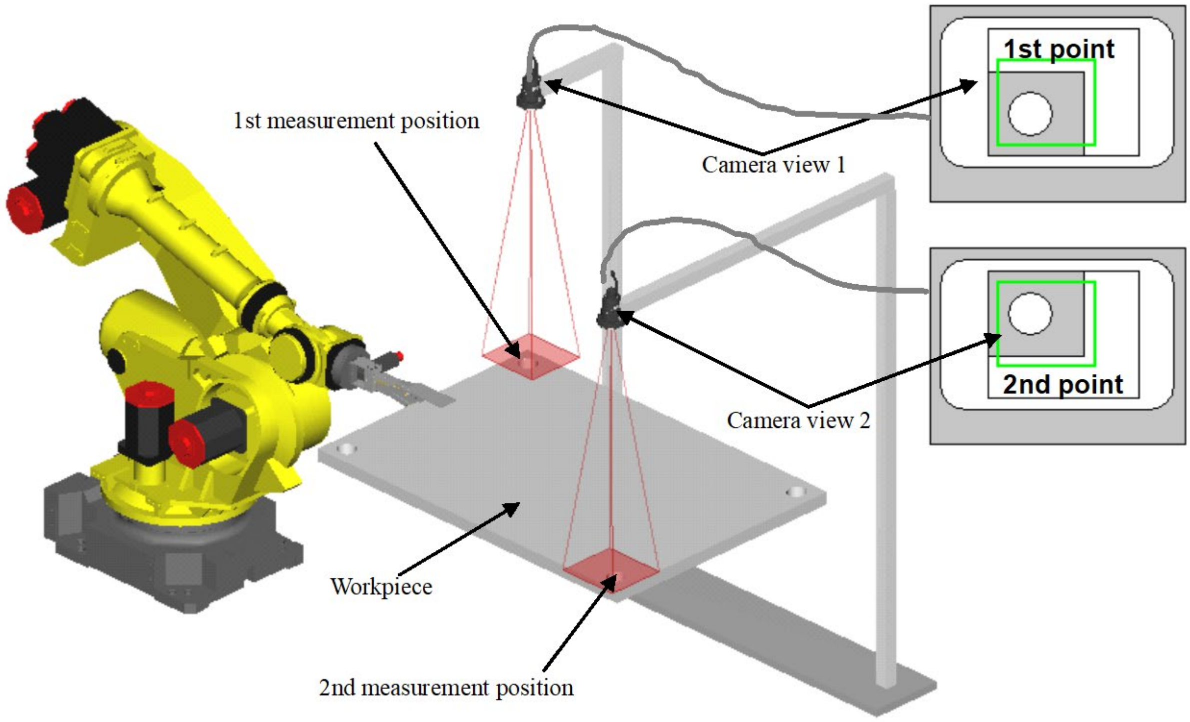


Offset frame setting

When the Robot-generated Grid Calibration is used, if the XY plane of the tool frame (UTool for work space) that is set in Know-how Edition Subsection 2.3.8, "Measuring target position" is parallel with the deviation plane of the workipece, the tool frame can be used as the offset frame. In this case, it is recommended to copy the values of the UTool for work space to another tool frame number and specify it as the offset frame number. For example, when the UTool for work space number is 9, copy the value of the UTool for work space to arbitrary another tool frame numbers (for example, the tool frame number is 1), and select the tool frame number as the offset frame.

2.4.3 Vision Process Creation and Teaching

Create a vision process and teach it.
The basic setting procedures are the same as the 2D Single-view Vision Process. The 2D Multi-view Vision Process uses the 'camera views'. Only in this regard, the 2D Multi-view Vision Process differs from the 2D Single-view Vision Process. For each measurement point, a camera view is named [camera view 1] or [camera view 2]. The snap tool and the locator tool such as the GPM Locator Tool are added under each camera view.



Vision process creation and teaching

The setup procedures for the 2D Multi-view Vision Process is shown below:

1. Teach the locator tool for [Camera View 1].

⇩

2. Click [SNAP] for [Camera View 1] to snap an image of the workpiece.

⇩

3. Teach the locator tool for [Camera View 2].

⇩

4. Click [SNAP] for [Camera View 2] to snap an image of the workpiece.

⇩

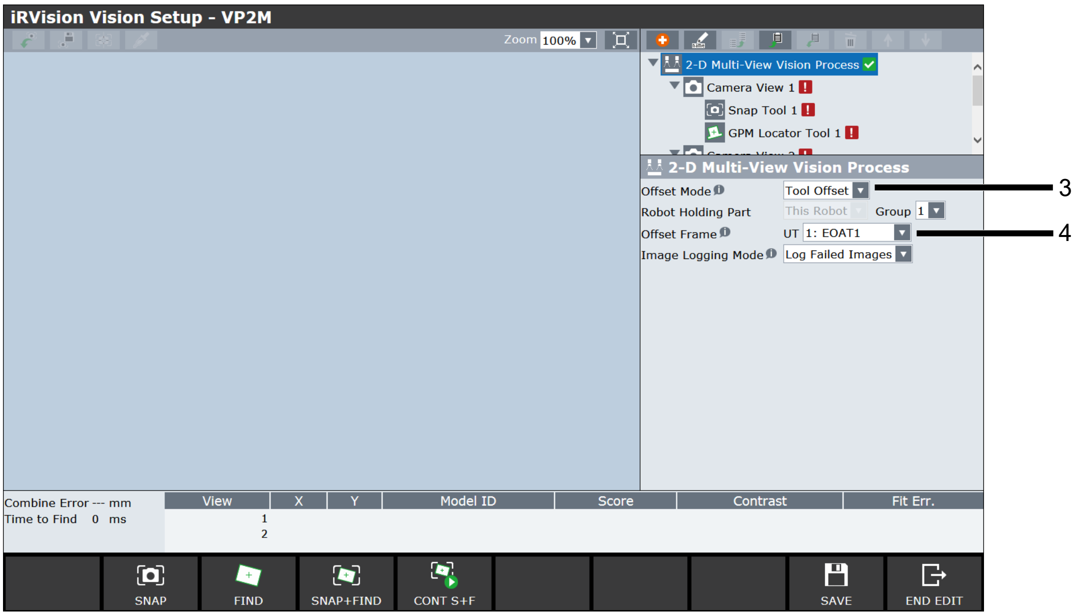
5. Select [Offset data Calculation Tool] and set a reference position.

Set the reference position without moving the workpiece after snapping the images of the workpiece by two camera views. Note that the snapped images will be cleared if the vision setup screen is closed. If reopened the vision setup screen, snap again the workpiece by the two camera views before trying to set the reference position again.

2.4.3.1 Vision process creation

1 Create a vision process for [2-D Multi-View Vision Process].
For details of vision process creation, refer to the description of creating new vision data in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, when the created vision process is selected and clicked [Edit], the vision data edit screen will appear.



3 From the [Offset Mode] drop-down box, select [Tool Offset].

4 From the [Offset Frame] drop-down box, select the tool frame to set.
Select the frame number specified in Setup Edition Subsection 2.4.2, "Offset Frame Setting."

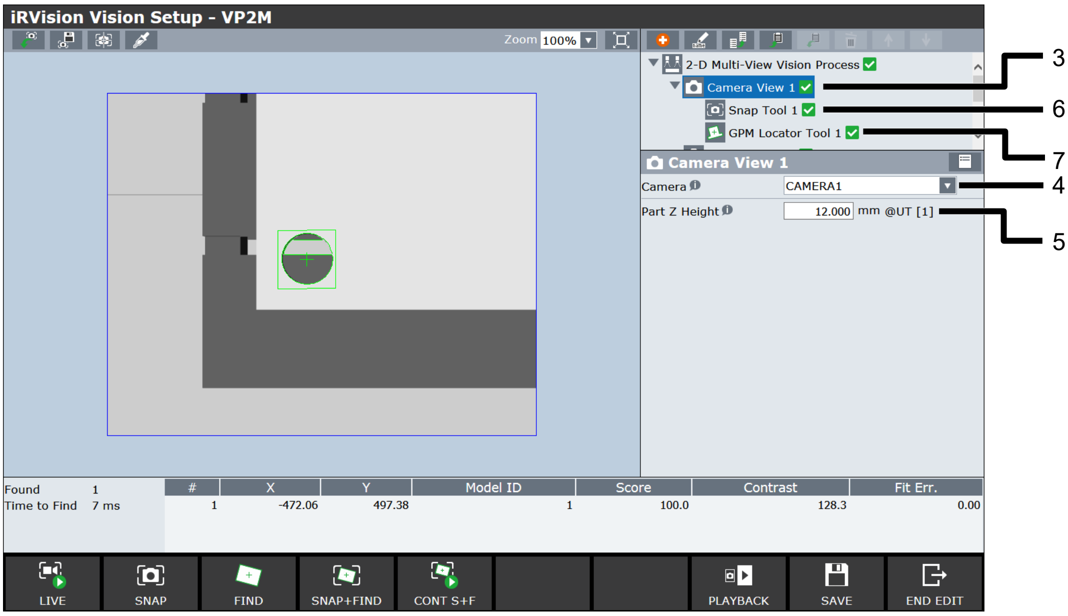
2.4.3.2 Camera view teaching

Teach the snap tool and the locator tool such as GPM Locator Tool, for each camera view.

1 Grip a workpiece with the robot.

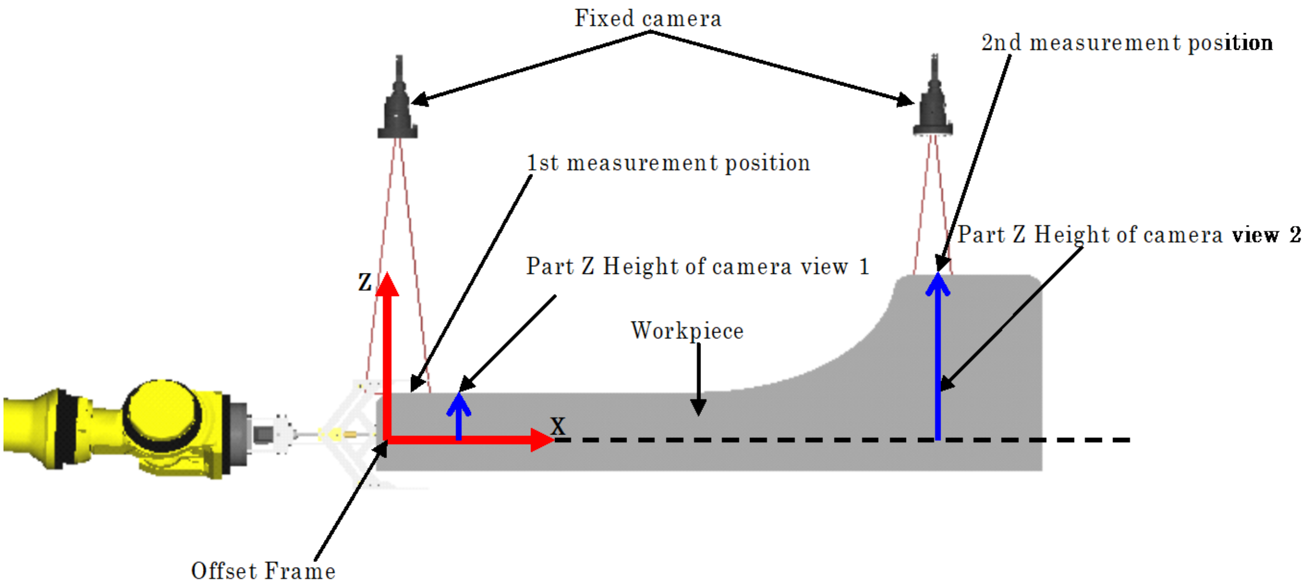
2 Move the robot to a position where the first detection part of the workpiece can be snapped.
Record this robot position as the first snap position. Refer to the sample program in Setup Edition Subsection 2.4.4, "Robot Program Creation and Teaching". P[1] in line 4 is the first snap position. Record the current robot position to P[1].

3 Select [Camera View 1] from the tree view.



4 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 2.4.1, "Camera Data Creation and Teaching".

5 In the text box for [Part Z Height], enter the height of the detected part of the workpiece.
If there is a distance between the XY plane of the offset frame and the measurement plane of the workpiece, enter the value.
Enter an appropriate value for each camera view as shown in the figure below.



Offset Frame and Part Z Height

6 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap window and the exposure time. For details, refer to the description of Snap Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

7 Select a locator tool from the tree view and teach the model used in detection.
By default, the GPM Locator Tool is set as the locator tool. For details of the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

8 Click [SNAP] to snap an image.
9 After [Camera View 1] setup is completed, repeat the steps from 2 to 8 for another camera view in the same way.

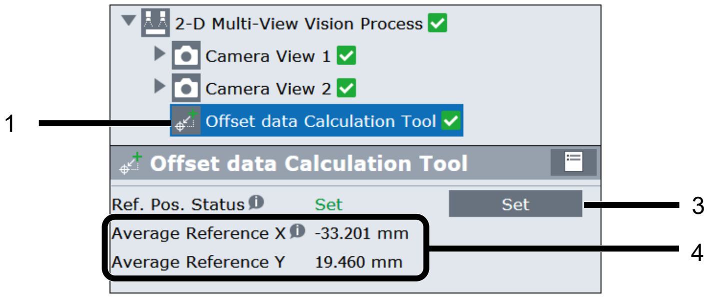
Memo
To add a camera view, select the vision process in the tree view and click the button.

2.4.3.3 Setting the reference position

1 Select [Offset data Calculation Tool] from the tree view.

CAUTION
Regarding the following steps, do not change the holding point of the workpiece until the reference position setting is completed.

2 Click [FIND] to find the workpiece.



3 Click the [Set] button for [Ref. Pos. Status]
4 Check that [Ref. Pos. Status] becomes [Set] and the values for [Average Reference X] and [Average Reference Y] is displayed.
The values are the position of the center of gravity of the workpiece on the offset frame.
5 Click [Save] and click [End Edit].
6 Move the robot to the position to work to the workpiece (e.g. place it).
For an example, refer to the sample program in Setup Edition Subsection 2.4.4, "Robot Program Creation and Teaching". P[3] in line 14 is the position to work to the workpiece. Record the current robot position on P[3], and the reference position setting is completed.

2.4.4 Robot Program Creation and Teaching

The sample program is shown below. A vision process [A] is used. Add the "VOFFSET, VR" instruction to the movement statement

```
 1:    UFRAME_NUM=1 ;
 2:    UTOOL_NUM=6 ;
 3:    R[1:Notfound]=0     ;
 4:L P[1] 2000mm/sec FINE     ;
 5:    WAIT R[1] ;
 6:    VISION RUN_FIND 'A' CAMERA_VIEW[1]     ;
 7:L P[2] 2000mm/sec FINE     ;
 8:    WAIT R[1] ;
 9:    VISION RUN_FIND 'A' CAMERA_VIEW[2]     ;
10:    VISION GET_OFFSET 'A' VR[1] JMP LBL[100] ;
11:      ;
12:    !Handling ;
13:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]     ;
14:L P[2] 500mm/sec FINE VOFFSET,VR[1]     ;
15:    CALL HAND_OPEN     ;
16:L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]     ;
17:    !Handling ;
18:    JMP_LBL[900] ;
19:      ;
20:    LBL[100] ;
21:    R[1:Notfound]=1     ;
22:      ;
23:    LBL[900] ;
```

Move the workpiece to the position to snap on line 4. Execute a "WAIT" instruction to remove the vibration of the workpiece on line 5. Execute a camera view 1 of program "A" with the vision detection instruction with the line 6. Move the workpiece to the position to snap at camera view 2 on line 7. Obtain the offset data of the detected workpiece on line 10. Move the robot to the approach position to place the workpiece on line 13. Since this is the approach position to the workpiece, add the position offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move the robot to the position where the robot places the workpiece on line 14. Move the robot to escape position after the workpiece is placed on line 16.

2.4.5 Robot Compensation Operation Check

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

- Place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of offset is low, set the reference position again.
- Move the workpiece without rotation, find it and check the handling accuracy. If the accuracy of offset is good on the reference position, but it is low for non-rotated workpiece on the edge of the field of view, it is possible that [Part Z Height] is not set properly. Refer to Setup Edition Subsection 2.4.3.2, "Camera view teaching" and make sure that [Part Z Height] is correctly set for the workpiece.
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy of offset is good on a workpiece without rotation, but it is low for rotated workpiece and lower for more rotated workpiece, it is possible the offset frame or the calibration grid frame is not set properly. When touch-up method is used to set up the frame, check the TCP setting is precise. Moreover, check the offset frame and the calibration grid frame are set precisely. If there is necessary, retry the camera calibration.
- Depending on robot motion, a workpiece may vibrate at snap position. Execute “WAIT” instruction to remove the vibration of a workpiece before the detection.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

> ✐ **Memo**
> If the workpiece cannot be found correctly due to a variation in the distances between measurement points, e.g., due to individual difference of workpieces, switch to the advanced mode in [Offset data Calculation Tool] and set [Combine Error Limit].

3 DEPALLETIZING VISION PROCESS

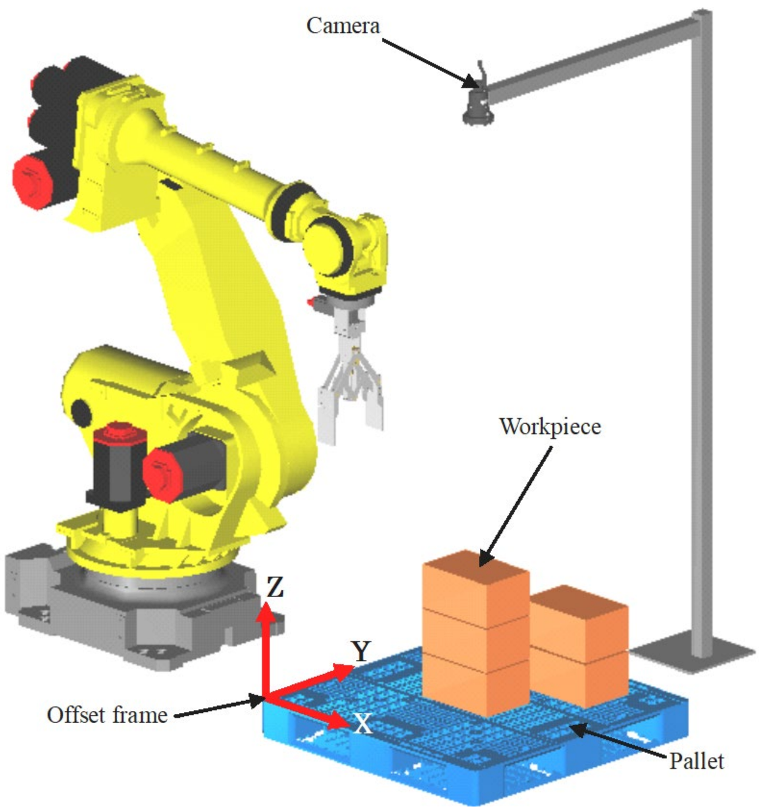
The Depalletizing Vision Process is a vision process that performs compensation in the vertical direction in addition to standard two-dimensional compensation. This function measures the height of the workpieces based on the size of the workpiece image viewed by the camera. This section explains the setup procedure for the Depalletizing Vision Process using the following two configurations as examples.

- "Fixed frame offset with fixed camera"
- "Fixed frame offset with robot-mounted camera"

For the each application, the basic program setting method is the same as for 2D Single-view Vision Process. However, the Depalletizing Vision Process differs from the 2D Single-view Vision Process about the method of reference position setting. Specifically, sets the relationship between the height of workpieces and the size of the workpiece viewed by the camera. In this point, the Depalletizing Vision Process differs from the 2D Single-view Vision Process.

Fixed frame offset with fixed camera

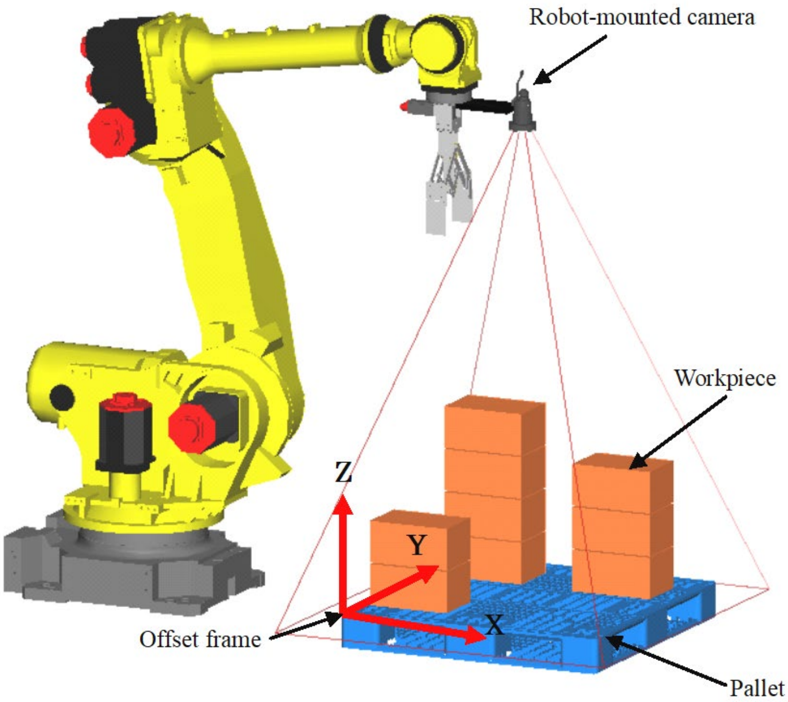
An example of layout for "fixed frame offset with fixed camera" is given below.



Example of layout for fixed frame offset with fixed camera

Fixed frame offset with robot-mounted camera

An example of layout for "fixed frame offset with robot-mounted camera" is given below.



Example of layout for fixed frame offset with robot-mounted camera

3.1 FEATURES AND NOTES

Features

- This function performs compensation in the vertical (Z) direction in addition to ordinary two-dimensional compensation.
- The height (standard Z coordinate) of the workpieces are measured based on the size of the workpiece image viewed by the camera.
- After an operation for picking up a workpiece from one location of the pallet is taught, a workpiece can be picked up from an arbitrary row/column/stage.
- For robot-mounted cameras, the camera can be moved in the X, Y, and Z directions of the offset frame in order to measure. This capability is provided because the current position of a robot is considered in *i*RVision calculation processing when a workpiece position calculation is made.

Notes

- As with the 2-D Single-View Vision Process, the fixed frame offset is applied to the XY and R directions. Therefore, it is assumed that each measurement plane is parallel to the XY plane of the offset frame, and not tilted.
- The camera position for measurement is determined from the thickness of a workpiece and the number of layers.
- When either a fixed camera or a robot-mounted camera is used, it is wanted that the optical axis of the camera is normal to the XY plane of the offset frame. When the camera is attached in a position that the optical axis of the camera is slantingly to the XY plane of the offset frame, it seems that the shape of the workpiece is distorted depending on the place of a field of view. In this case, it is possible that detection of the workpiece become difficult.

- In order to absorb measurement errors in the App. Z Mode direction, it is recommended that you prepare for the gripper a floating mechanism in the forwarding direction and a sensor for sensing contact with the workpiece. For example, you can use a read switch of the cylinder and high speed skipping to escape a robot hand when the hand and the workpiece contacts accidentally.
- The height of the workpieces are measured based on the size of the workpiece image viewed by the camera. As a guideline, two workpieces found one layer apart should have a difference in size by at least 5%.
- As the distance between the camera and workpiece increases, the precision in height measurement is degraded. So, minimize this distance whenever possible.
- As the distance between the camera and workpieces increases, the precision in height measurement is degraded. If a workpiece to be measured is located far away, the workpiece can be measured again by approaching the workpiece if the camera is robot-mounted. In this case, the same vision program can be used. This is because the current position of the robot is considered when a workpiece position calculation is made.
- Ensure that the camera focuses on both the workpiece at the top and the workpiece at the bottom.
- Ensure that lighting is provided evenly to the workpiece at the top and the workpiece at the bottom whenever possible. This is a key to stable workpiece detection and precise size measurement. When a robot-mounted camera is used, it is recommended to install a ring light around the camera.

3.2 SETUP FOR FIXED FRAME OFFSET WITH FIXED CAMERA

Use the following setup procedure for "fixed frame offset with fixed camera":

1. Camera Data Creation and Teaching

⇩

2. Offset frame setting

⇩

3. Vision process creation and teaching

⇩

4. Robot program creation and teaching

⇩

5. Robot Compensation Operation Check

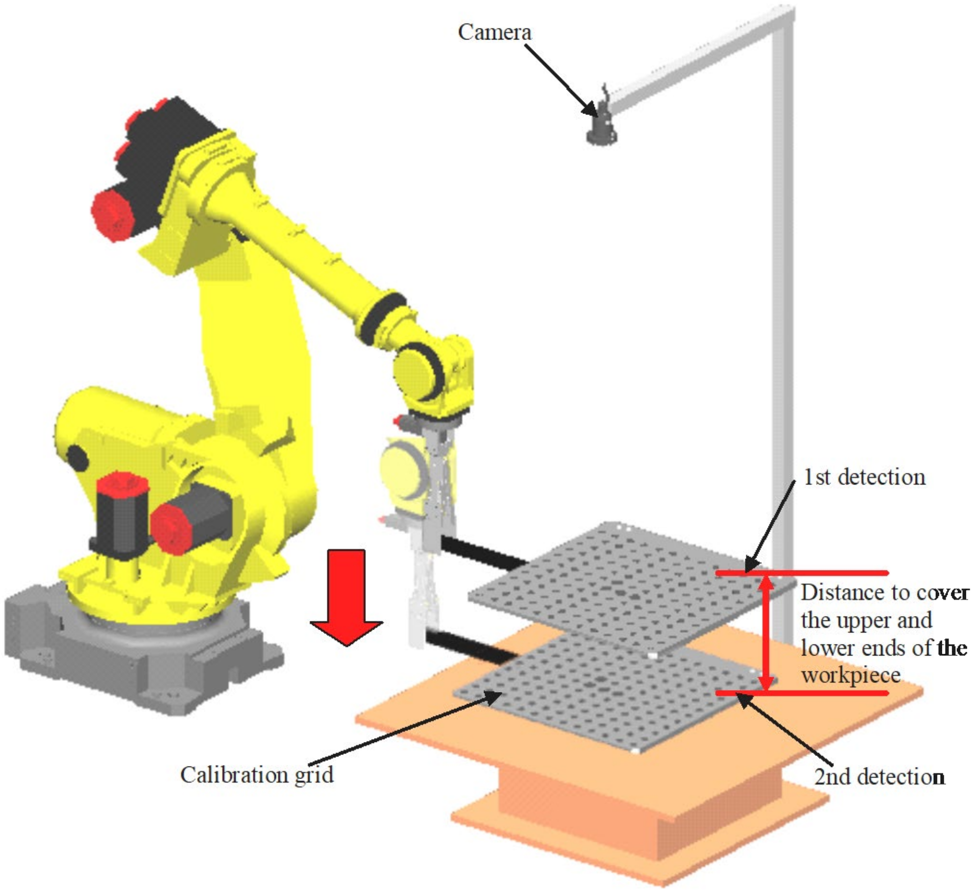
When starting up a robot system that uses *i*RVision, perform all of the tasks described above. When the position of the fixed camera is shifted or cameras are exchanged, redo "1 Camera Data Creation and Teaching". When a camera calibration has been already finished, in addition, a workpiece is changed or a kind of workpiece is added, perform "3 Vision process creation and teaching". and "4 Robot program creation and teaching".

3.2.1 Camera Data Creation and Teaching

Create camera data and perform basic settings and calibration for the camera.
There are two kinds of methods for a camera calibration, those are Grid Pattern Calibration and Robot-generated Grid Calibration.

Grid Pattern Calibration

If you install a calibration grid on the gripper, make the vertical movement distance for when calibrating with two planes something that will cover the upper and lower ends of workpiece distribution in the pallet.



Installation example for Grid Pattern Calibration

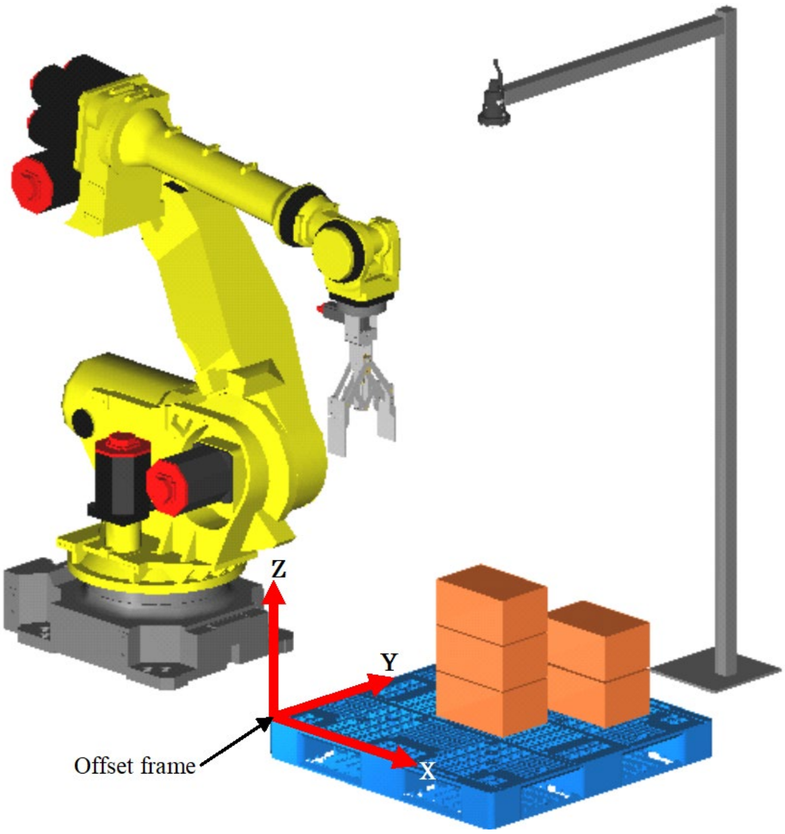
For the setup method for Grid Pattern Calibration, refer to Know-how Edition Section 2.1, " GRID PATTERN CALIBRATION WITH A FIXED CAMERA".

Robot-generated Grid Calibration

When you perform 2-D Single-View Vision Process, robot-generated grid calibration is suitable because a field of view size tends to broaden. For the setup method for robot-generated grid calibration, refer to Know-how Edition Section 2.3, "ROBOT-GENERATED GRID CALIBRATION".

3.2.2 Offset Frame Setting

An offset frame is a coordinate system used for calculation of the offset data. A found position is outputted as a position in the offset frame. In the fixed frame offset, the offset frame is set as a user frame.
Set an offset frame so that the XY plane of the offset frame is parallel with the table plane on which the workpiece is placed. Otherwise, the required compensation precision may not be obtained.



Offset frame setting

There are two methods to teach the offset frame, one is touch-up with the pointer tool, and another is the Automatic Grid Frame Setting Function.

Touch-up

To teach with touch-up with a pointer tool, a pointer tool with correct TCP setting is required. In general, set the TCP accurately at the tip of pointer tool attached to the robot hand. If the accuracy of this TCP setting is low, the precision in handling of a workpiece by the robot is also degraded, especially when the workpiece is rotated. Set a robot TCP in an arbitrary tool coordinate system. To reuse the pointer TCP, the reproducibility of pointer installation is required. If the reproducibility of pointer installation is not assured, a TCP needs to be set each time a pointer is installed. For details, refer to Know-how Edition Subsection 1.1.1, “User frame setting”.

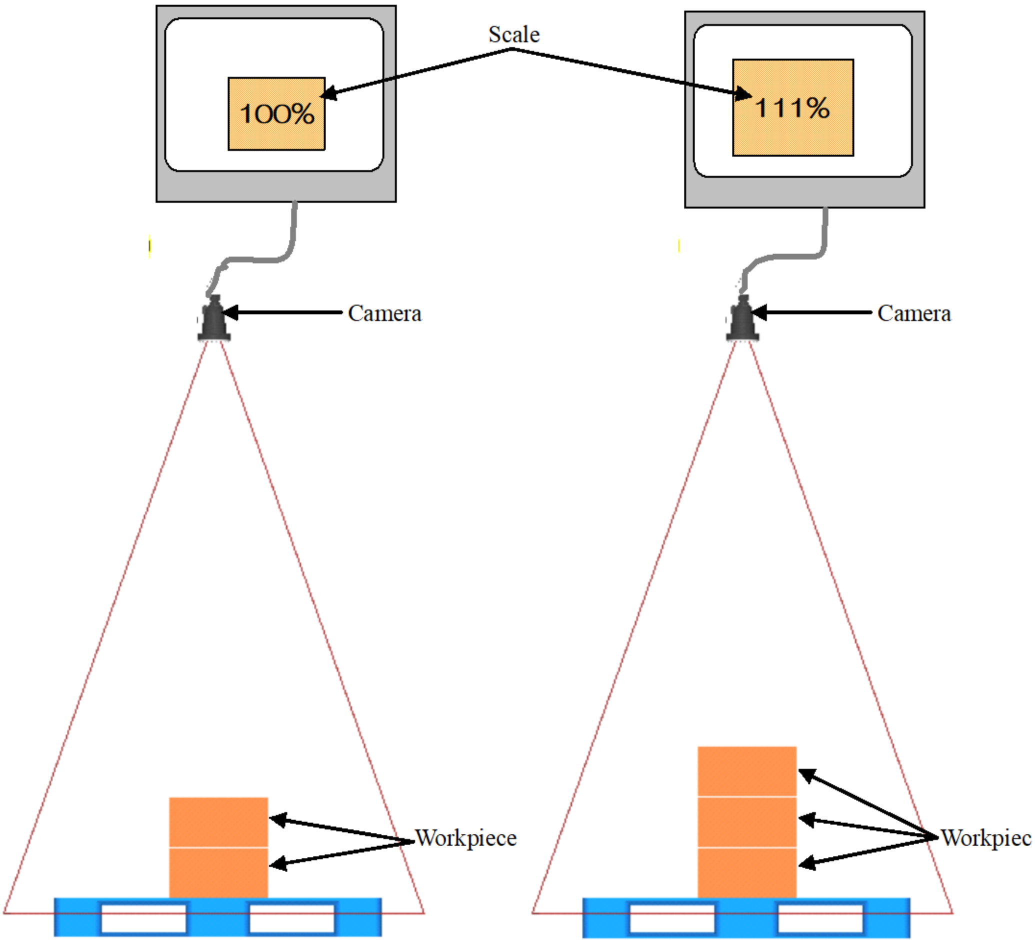
Grid Frame Set

The Grid Frame Setting Function sets the calibration grid frame using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane on which the workpiece is placed, and perform the Grid Frame Setting Function. For details, refer to Know-how Edition Section 1.2, “FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION”. A calibration grid is used for a setup. Moreover, in the case of a fixed camera, prepare a camera for the Grid Frame Setting Function separately. And perform the Grid Frame Setting Function using the camera attached to the arbitrary positions of a robot's hand. In addition, the Grid Frame Setting Function is usable with 6-axis robots only. The function cannot be used with 4-axis robots and 5-axis robots. When using 4-axis robots or 5-axis robots, perform the touch-up to set a frame.

3.2.3 Vision Program Creation and Teaching

Perform vision process creation and teaching. Perform teaching about the locator tools and set the reference position.

The basic program setting method is the same as for 2D Single-view Vision Process. Unlike 2D Single-view Vision Process, Depalletizing Vision Process sets the relationship between the height of workpieces and the size of the workpiece viewed by the camera.

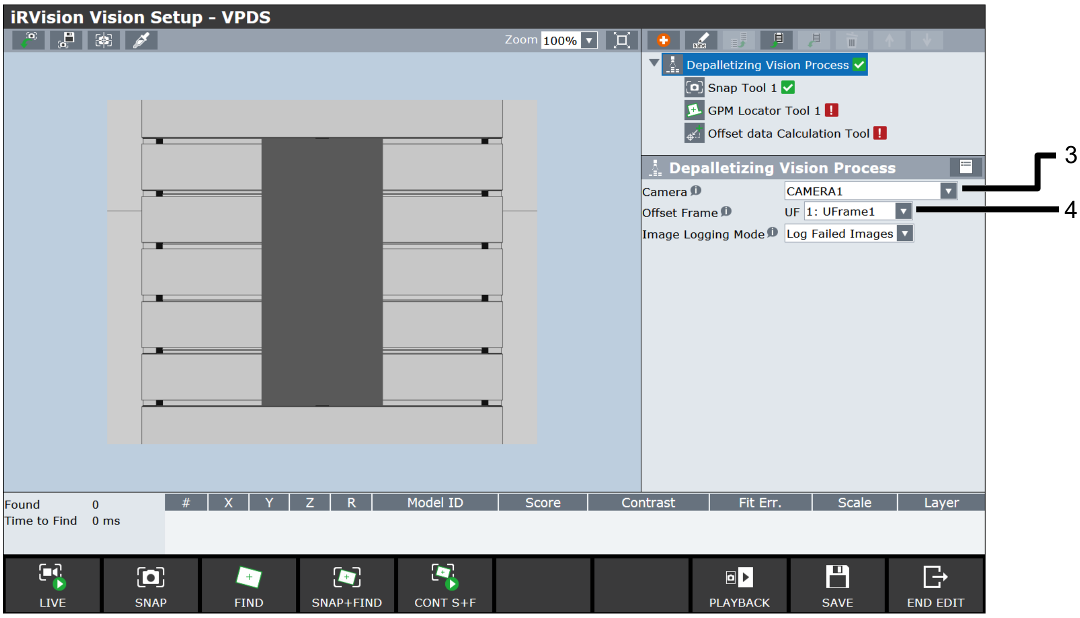


Vision process creation and teaching

3.2.3.1 Vision process creation

1 Create a vision process for [Depalletizing Vision Process].
For details on vision process creation, refer to the description of creating new vision data in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, if you select the created vision process and click [EDIT], the vision data edit screen will appear.

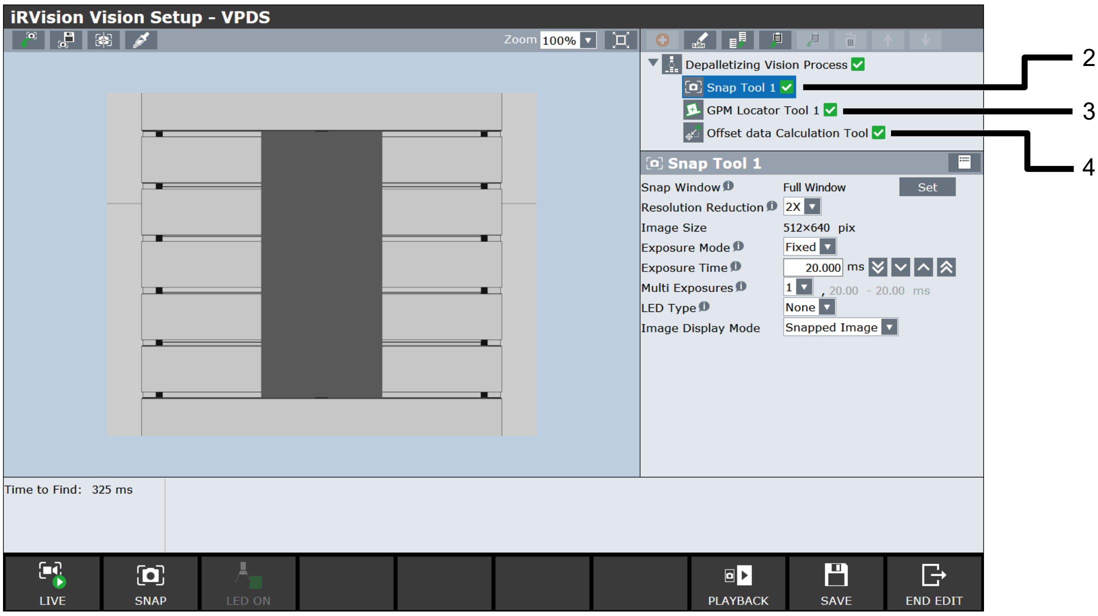


3 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 3.2.1, " Camera Data Creation and Teaching".

4 From the [Offset Frame] drop-down box, select the user frame to set.
Select the frame number specified in Setup Edition Subsection 3.2.2, "Offset Frame Setting."

3.2.3.2 Command tool teaching

1 Put a workpiece in place.



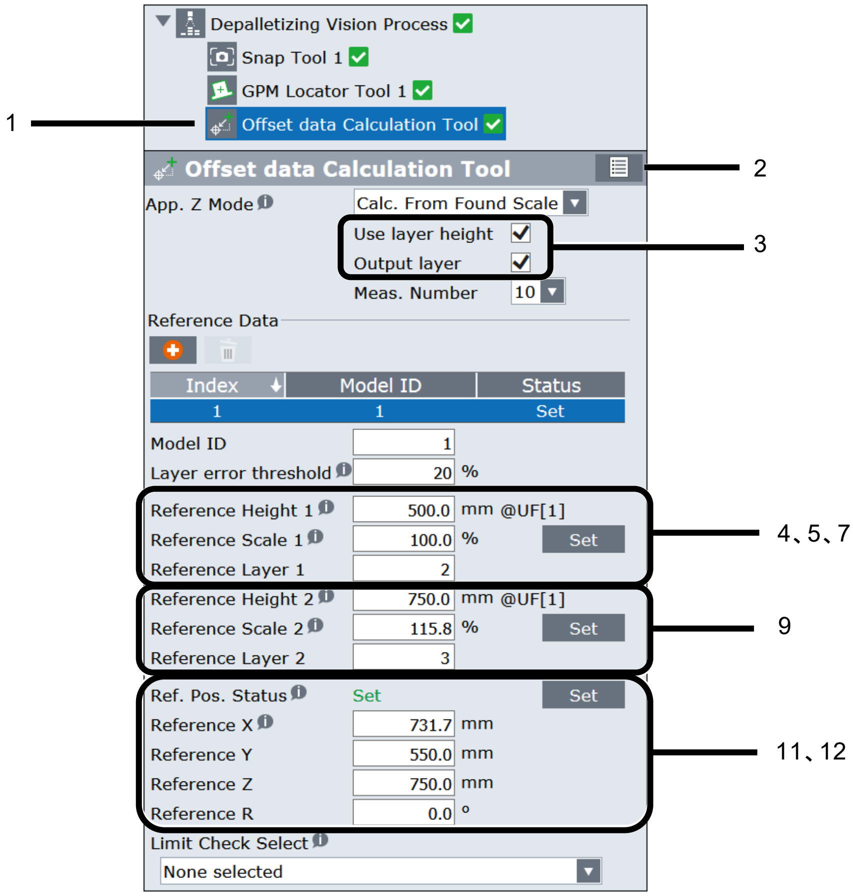
2 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap range and exposure time. For details, refer to the description of Snap Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

3 Select a locator tool in the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details on the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

4 When the snap tool and the locator tool are set, set the reference position in the offset data calculation tool. Refer to 3.2.3.3, "Reference position setting" for the setting.

3.2.3.3 Reference position setting

1 Select [Offset data Calculation Tool] from the tree view.

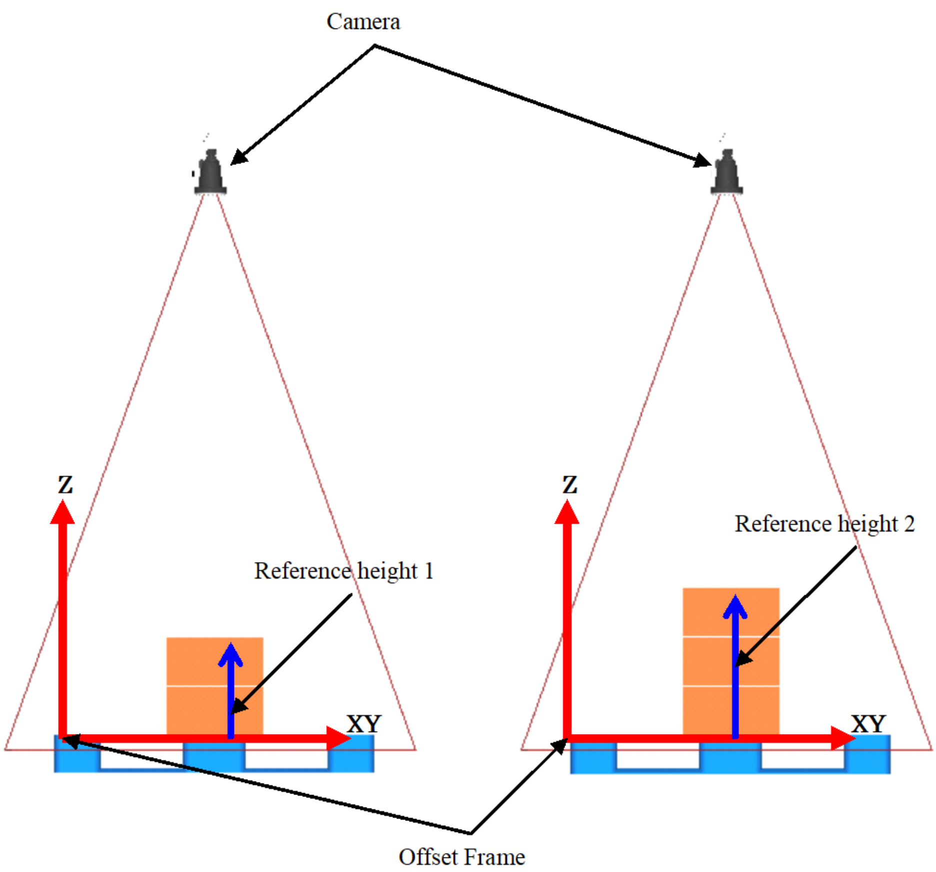


2 Click the  icon to switch to the advanced mode.
3 Check [Use layer height] and [Output layer].

Memo

1 When [Use layer height] is checked, it identifies which layer the target workpiece is located on according to the size of the workpiece found in the vision process and calculates the workpiece position based on the height information of the corresponding layer. Since the same height information is applied for each layer, stable height information can be used even when there are differences in size. Use this function when a workpiece has large differences in height.
2 When [Output layer] is checked, it outputs the identified workpiece layer as a measurement value to the vision register. This is useful for a program that moves the robot differently for each layer of the workpiece. Specify the output measurement number in [Meas. Number].

4 Enter the number of layers in the text box of [Reference Layer 1].
5 Measure the part height of a workpiece of [Reference Layer 1] as seen from the offset frame, and enter it in the text box of [Reference Height 1].
Enter appropriate values as shown in the figure below.



Offset frame and part Z height

6 Click [SNAP] to snap the image, and click [FIND] to detect the workpiece for [Reference Layer 1].
7 Click the [Set] button for [Reference Scale 1].
A value will be displayed in [Reference Scale 1], and a reference scale will be set.
8 Stack N layers of workpieces, and enter the number of layers in the text box of [Reference Layer 2].
9 Carry out steps 5 to 7 for [Reference Layer 2].
10 When [Reference Scale 2] is set, click [FIND] again to find the workpiece.

> ⚠ **CAUTION**
> Do not move the workpiece until reference position setting is complete.

11 Click the [Set] button for [Ref. Pos. Status].
12 Check that [Ref. Pos. Status] has become [Set].
13 Jog the robot and move it to the position for performing work on the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 3.2.4, "Robot Program Creation and Teaching". P[2] in line 11 is the position for performing work on the workpiece. Record the current robot position to P[2], and the reference position setting is complete.

3.2.4 Robot Program Creation and Teaching

In the sample program below, a vision process named "A" is used. For fixed frame offset, add the "VOFFSET, VR" instruction as an operation statement.


```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  R[1:Notfound]=0
 4:  L P[1] 2000mm/sec FINE
 5
 6:  VISION RUN_FIND 'A'
 7:  VISION GET_OFFSET 'A' VR[1] JMP LBL[100]
 8:
 9:  !Handling
10:  L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[2]
11:  L P[2] 500mm/sec FINE VOFFSET,VR[1]
12:  CALL HAND_CLOSE
13:  L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]
14:  !Handling
15:  JMP_LBL[900]
16:
17:  LBL[100]
18:  R[1:Notfound]=1
19:
20:  LBL[900]
```

Obtain the offset result of the detected workpiece on line 7. Move to the position above the workpiece on line 10. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move to the grasp position on line 11. Move to the escape position after grasping the workpiece on line 13.

3.2.5 Robot Compensation Operation Check

Check that a workpiece placed on the pallet can be detected and handled precisely.

- Place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting.
- Move the workpiece without rotation, find it and check the handling accuracy. If the accuracy is good for the reference position, but low for non-rotated workpiece on the edge of the field of view, it is possible that Part Z Height is not set properly. Check the [Part Z Height], refer to Setup Edition Subsection 3.2.3.3, “Reference position setting”.
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy is good for a moved workpiece without rotation, but low for rotated workpiece and lower for more rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. When performing the touch-up with pointer tool to set up the frame, check the TCP setting is precise. Moreover, check the offset frame and the calibration grid frame are set precisely, then retry the camera calibration.
- Stack several workpieces then move the robot to the top workpieces. Check that the robot moves to the workpieces correctly. Remove the workpiece and repeat with the next workpiece. Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

3.3 SETUP FOR FIXED FRAME OFFSET WITH ROBOT-MOUNTED CAMERA

Use the following setup procedure:

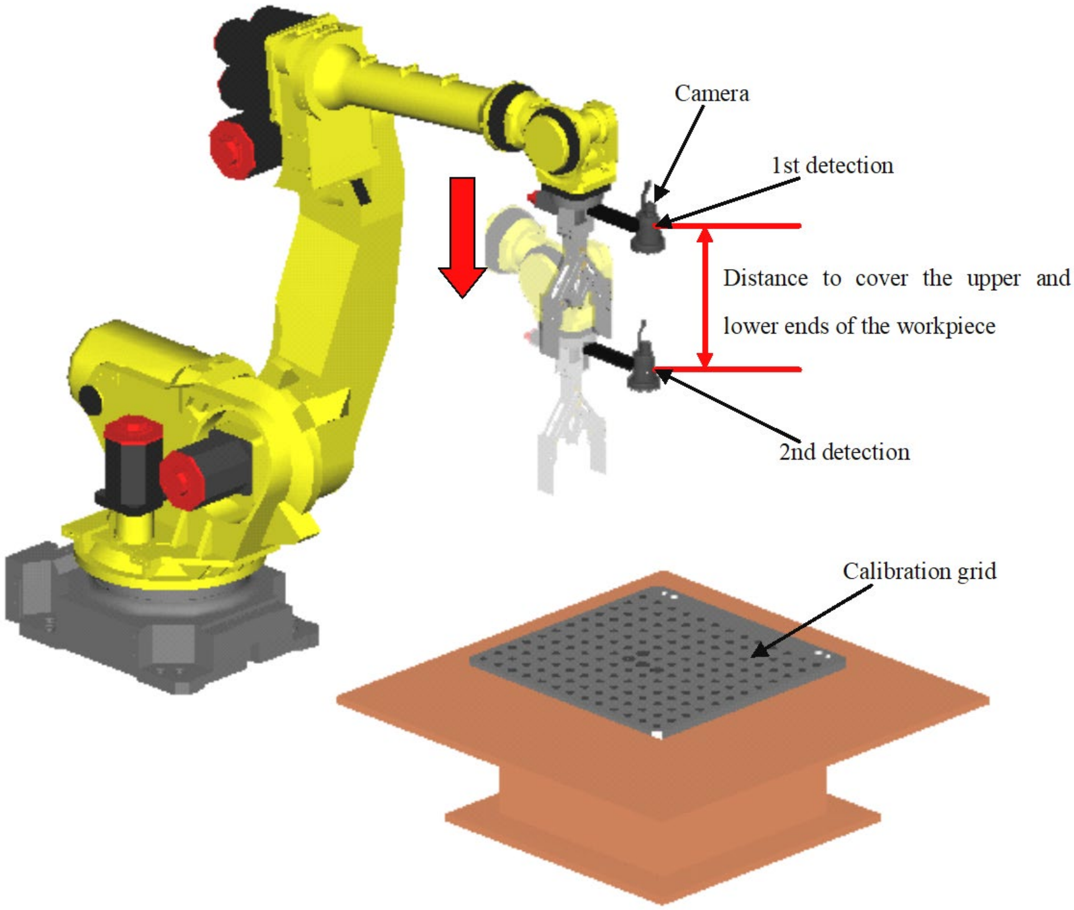
1. Camera Data Creation and Teaching
2. Offset frame setting
3. Vision process creation and teaching
4. Robot program creation and teaching
5. Robot Compensation Operation Check

When starting up a robot system that uses *i*RVision, perform all of the tasks described above. When the position of the camera on the robot mechanical interface frame (the robot face plane) is shifted or cameras are exchanged, redo "1 Camera Data Creation and Teaching". When a camera calibration has been already finished, in addition, a workpiece is changed or a kind of workpiece is added, perform "3 Vision process creation and teaching." and "4 Robot program creation and teaching."

3.3.1 Camera Data Creation and Teaching

Create camera data and perform basic settings and calibration for the camera.

Use Grid Pattern Calibration for a robot-mounted camera calibration. Robot-Generated Grid Calibration cannot be used for robot-mounted cameras. If you install a calibration grid on the gripper, make the vertical movement distance for when calibrating with two planes something that will cover the upper and lower ends of workpiece distribution in the pallet.

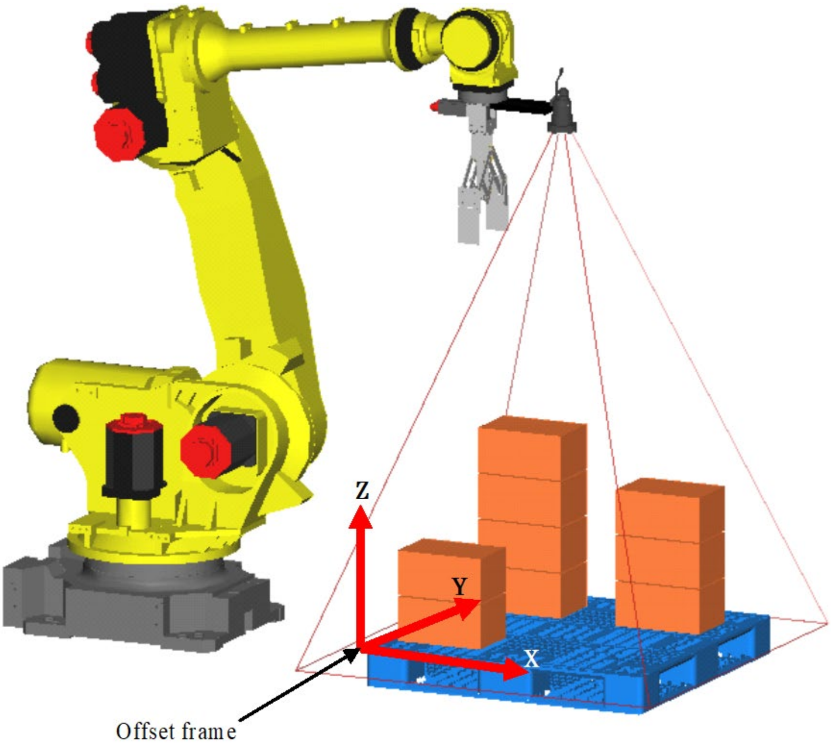


Installation example for Grid Pattern Calibration of robot-mounted camera

For the setup method for Grid Pattern Calibration, refer to Know-how Edition Section 2.2, "GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA".

3.3.2 Offset Frame Setting

An offset frame is a coordinate system used for calculation of the offset data. A found position is outputted as a position in the offset frame. In the fixed frame offset, the offset frame is set as a user frame.
Set an offset frame so that the XY plane of the user frame is parallel with the table plane on which a workpiece is placed. Otherwise, the required compensation precision may not be obtained.



Offset frame setting

There are two methods to teach the offset frame, one is touch-up with the pointer tool, and another is the Automatic Grid Frame Setting Function.

Touch-up

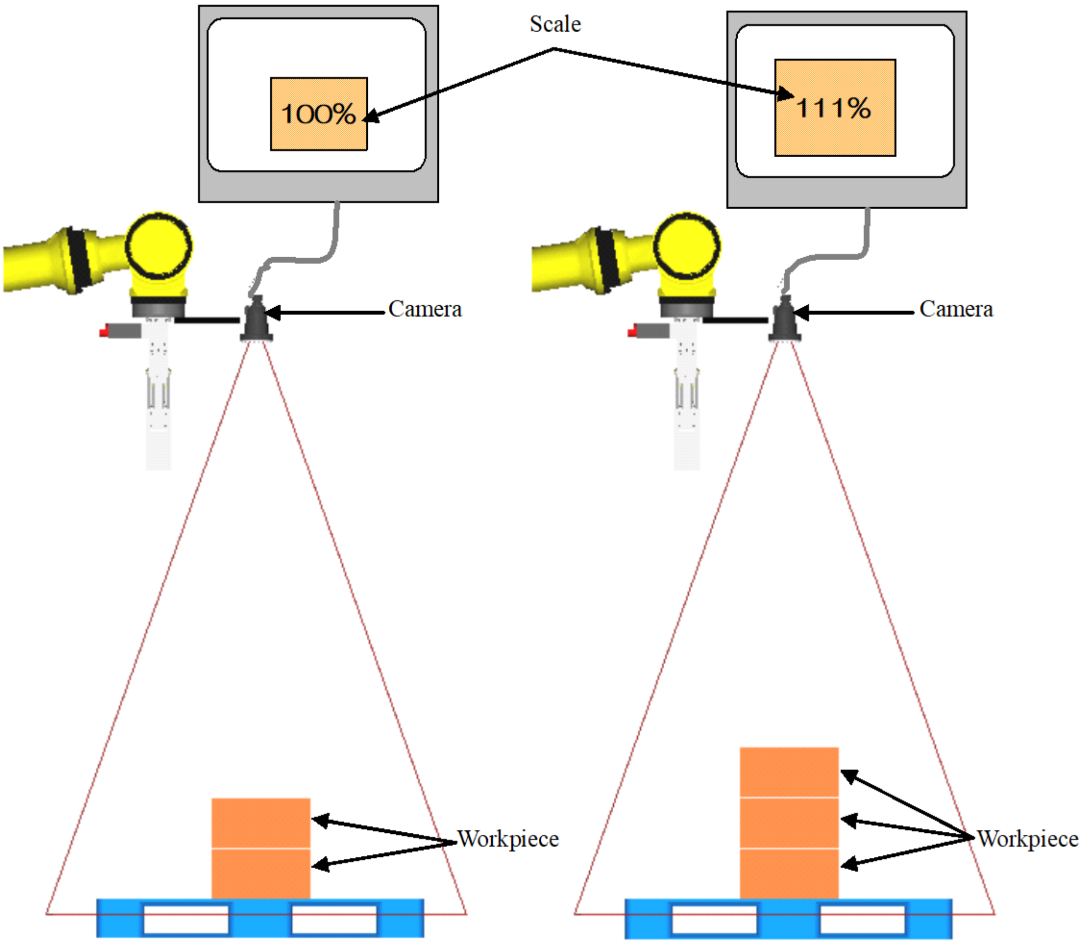
To set up by touch-up, a pointer tool with a taught TCP is required. In general, set the TCP accurately on the pointer installed on the robot gripper. If the accuracy of this TCP setting is low, the precision in handling of a workpiece by the robot is also degraded, especially when the workpiece is rotated. Set a robot TCP in an arbitrary tool coordinate system. To reuse the pointer TCP, the reproducibility of pointer installation is required. If the reproducibility of pointer installation is not assured, a TCP needs to be set each time a pointer is installed. For details, refer to Know-how Edition Subsection 1.1.1, “User frame setting”.

Grid Frame Setting Function

The Grid Frame Setting Function sets the calibration grid frame using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane on which the workpiece is placed, and perform the Grid Frame Setting Function. For details, refer to Know-how Edition Section 1.2, “FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION”. A calibration grid is used for a setup. In the case of a robot-mounted camera, the Grid Frame Setting Function can be performed with the camera currently used. When there is not sufficient space to perform Grid Frame Setting Function with the camera currently used, prepare another robot-mounted camera and Grid Frame Setting Function can be performed. In addition, the Grid Frame Setting Function is usable with 6-axis robots only. The function cannot be used with 4-axis robots and 5-axis robots. When using a 4-axis robots or 5-axis robots, perform the touch-up to set a frame.

3.3.3 Vision Process Creation and Teaching

Perform vision process creation and teaching. Perform teaching about the locator tools and set the reference position.
Unlike 2D Single-view Vision Process, Depalletizing Vision Process sets the relationship between the height of workpieces and the size of the workpiece viewed by the camera.

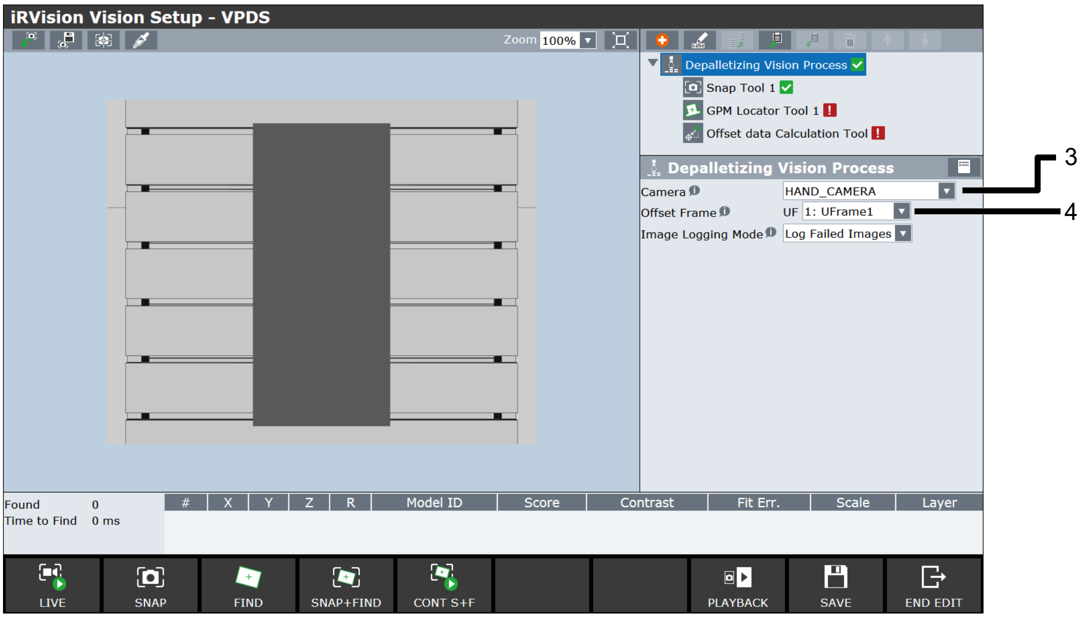


Vision process creation and teaching

3.3.3.1 Vision process creation

1 Create a vision process for [Depalletizing Vision Process].
For details on vision process creation, refer to the description of creating new vision data in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, if you select the created vision process and click [EDIT], the vision data edit screen will appear.

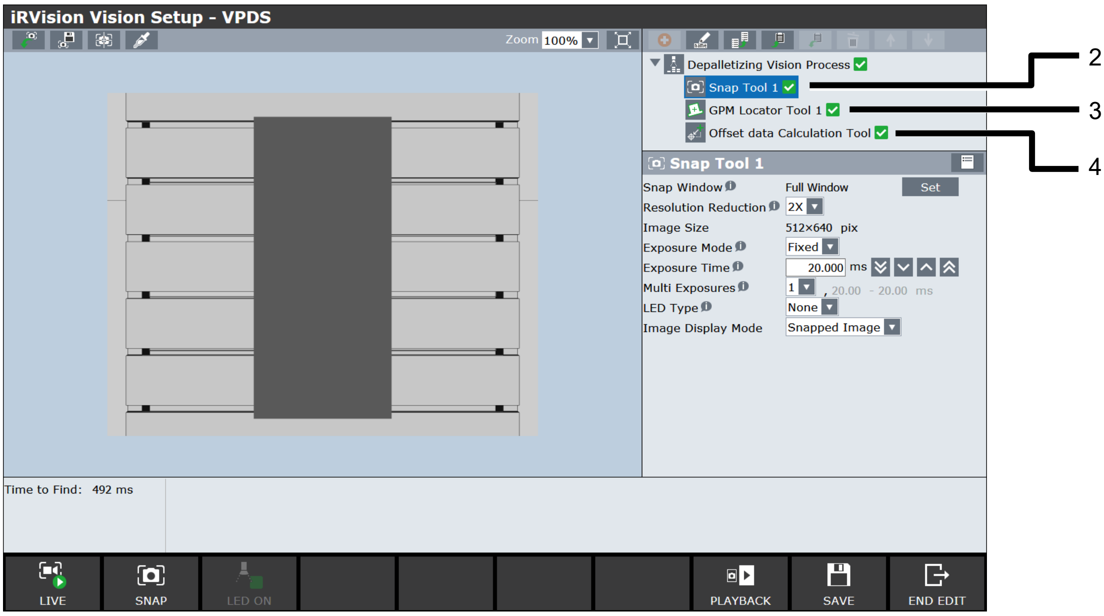


3 From the [Camera] drop-down box, select the camera data to be used.
For details, refer to Setup Edition Subsection 3.3.1, "Camera Data Creation and Teaching".

4 From the [Offset Frame] drop-down box, select the user frame to set.
Select the frame number specified in Setup Edition Subsection 3.2.2, "Offset Frame Setting".

3.3.3.2 Command tool teaching

1 Put a workpiece in place.



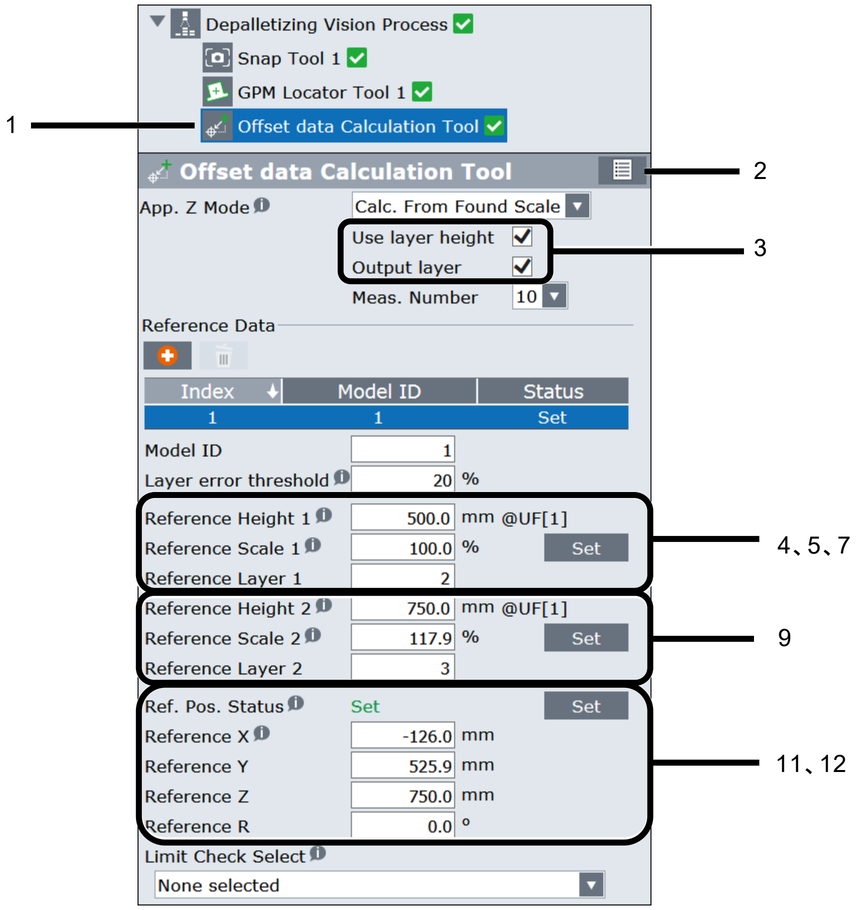
2 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap range and exposure time. For details, refer to the description of Snap Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

3 Select a locator tool in the tree view and teach the model to use for detection. By default, the GPM Locator Tool is set as the locator tool. For details on the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

4 When the snap tool and the locator tool are set, set the reference position in the offset data calculation tool. Refer to 3.3.3.3, "Reference position setting" for the setting.

3.3.3.3 Reference position setting

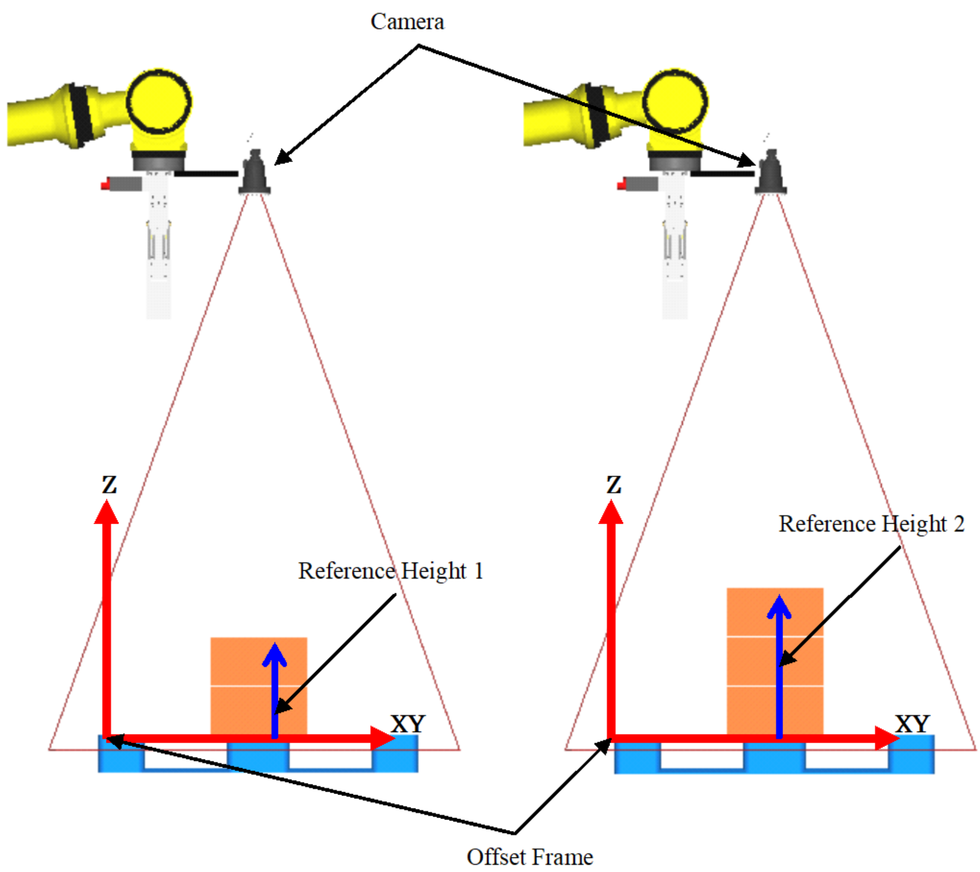
1 Select [Depalletizing Vision Process] in the tree view.



2 Click the icon to switch to the advanced mode.
3 Check [Use layer height] and [Output layer].

> **Memo**
> 1 When [Use layer height] is checked, it identifies which layer the target workpiece is located on according to the size of the workpiece found in the vision process and calculates the workpiece position based on the height information of the corresponding layer. Since the same height information is applied for each layer, stable height information can be used even when there are differences in size. Use this function when a workpiece has large differences in height.
> 2 When [Output layer] is checked, it outputs the identified workpiece layer as a measurement value to the vision register. This is useful for a program that moves the robot differently for each layer of the workpiece. Specify the output measurement number in [Meas. Number].

4 Enter the number of layers in the text box of [Reference Layer 1].
5 Measure the part height of a workpiece of [Reference Layer 1] as seen from the offset frame, and enter it in the [Reference Height 1] text box.
Enter appropriate values as shown in the figure below.



Offset frame and part Z height

6 Click [SNAP] to snap the image, and click [FIND] to detect the workpiece for [Reference Layer 1].
7 Click the [Set] button for [Reference Scale 1].
A value will be displayed in [Reference Scale 1], and a reference scale will be set.
8 Stack N layers of workpieces, and enter the number of layers in the [Reference Layer 2] text box.
9 Carry out steps 5 to 8 for [Reference Layer 2].
10 When [Reference Scale 2] is set, click [FIND] again to find the workpiece.

> ⚠ **CAUTION**
> Do not move the workpiece until reference position setting is complete.

11 Click the [Set] button for [Ref. Pos. Status].
12 Check that [Ref. Pos. Status] has become [Set].
13 Jog the robot and move it to the position for performing work on the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 3.3.4, "Robot Program Creation and Teaching". P[2] in line 11 is the position for performing work on the workpiece. Record the current robot position to P[2], and the reference position setting is complete.

3.3.4 Robot Program Creation and Teaching

In the sample program below, a vision process named "A" is used. A robot-mounted camera is used, and the "OFFSET" instruction is used on line 4 to shift the camera image snap position on the pallet. Shifting the image snap robot position by adding a constant value to the value of PR[1] simplifies programming. For fixed frame offset, add the "VOFFSET,VR" instruction as an operation statement.

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  R[1:Notfound]=0
 4:  L P[1] 2000mm/sec FINE Offset,PR[1]
 5:  WAIT R[1]
 6:  VISION RUN_FIND 'A'
 7:  VISION GET_OFFSET 'A' VR[1] JMP LBL[100]
 8:
 9:  !Handling
10:  L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[2]
11:  L P[2] 500mm/sec FINE VOFFSET,VR[1]
12:  CALL HAND_CLOSE
13:  L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[3]
14:  !Handling
15:  JMP_LBL[900]
16:
17:  LBL[100]
18:  R[1:Notfound]=1
19:
20:  LBL[900]
```

Move to camera position to snap on line 4. Execute “WAIT” instruction to remove the possible vibration of a camera on line 5. Execute process ”A” with the vision detection instruction on line 6. Obtain the measurement result of the detected workpiece on line 7. Move to the approach position above the workpiece on line10. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move to the grasp position on line11. Move to the escape position after grasping the workpiece on line13.

3.3.5 Robot Compensation Operation Check

Check that a workpiece placed on the pallet can be detected and handled precisely.

- Place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting.
- Move the workpiece without rotation, find it and check the handling accuracy. If the accuracy is good for reference position, but low for non-rotated workpiece on the edge of the field of view, it is possible that Part Z Height is not set properly. Check the Part Z Height, refer to Setup Edition Subsection 3.3.3.3, “ Reference position setting”
- Rotate the workpiece, find it and check the handling accuracy. If the accuracy is good for a moved workpiece without rotation, but low for rotated workpiece and lower for more rotated workpiece, it is possible that the offset frame or the calibration grid frame is not set properly. Check the TCP setting is precise. Moreover, check the offset frame and the calibration grid frame are set precisely, then, retry the camera calibration.
- Depending on robot motion, a camera may vibrate at snap position. Execute “WAIT” instruction to remove the possible vibration of a workpiece before the “VISION RUN_FIND”.
- Stack several workpieces then move the robot to the top workpieces. When performing the touch-up with pointer tool to set up the frame, check that the robot moves to the workpieces correctly. Remove the workpiece and repeat with the next workpiece. Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

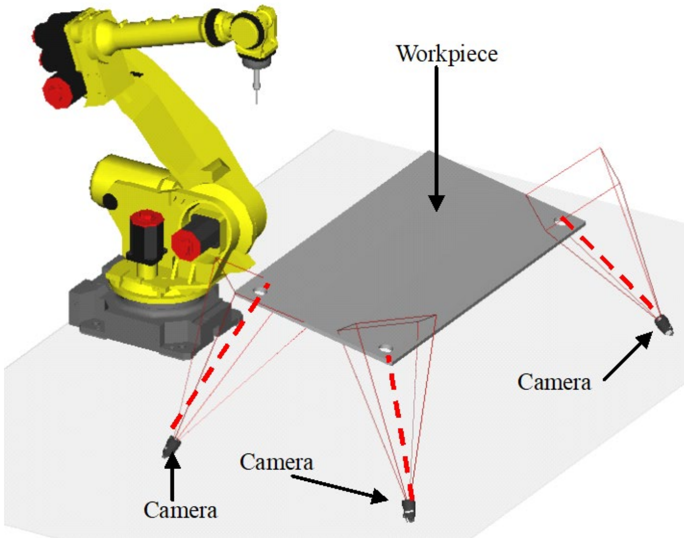
4 3D TRI-VIEW VISION PROCESS

The 3D Tri-View Vision Process is the function for making three-dimensional compensation by measuring three detection targets of a large workpiece such as a car body.
This chapter describes the setup procedure for 3D Tri-View Vision Process by using the following two application examples:

- Fixed frame offset with fixed camera
- Fixed frame offset with robot mounted camera

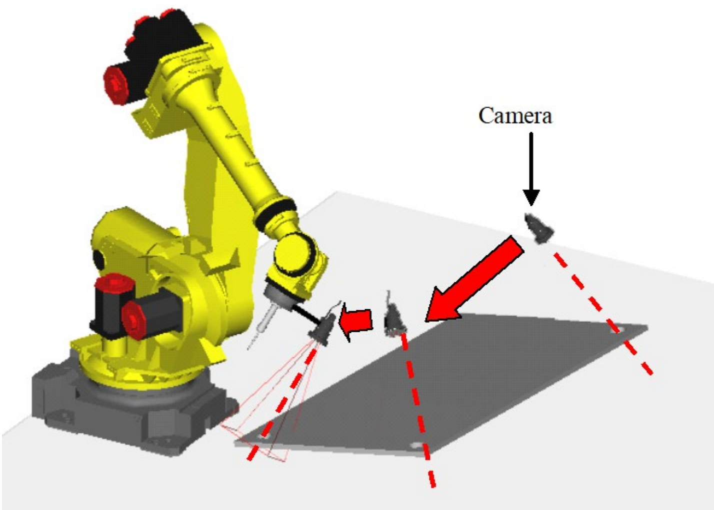
Fixed frame offset with fixed camera

An example of layout for 'fixed frame offset with fixed camera' is given below. Three points of a workpiece are measured by three fixed cameras.



Fixed frame offset with robot mounted camera

An example of layout for 'fixed frame offset with robot mounted camera' is given below. Three points of a workpiece are measured by moving a camera.



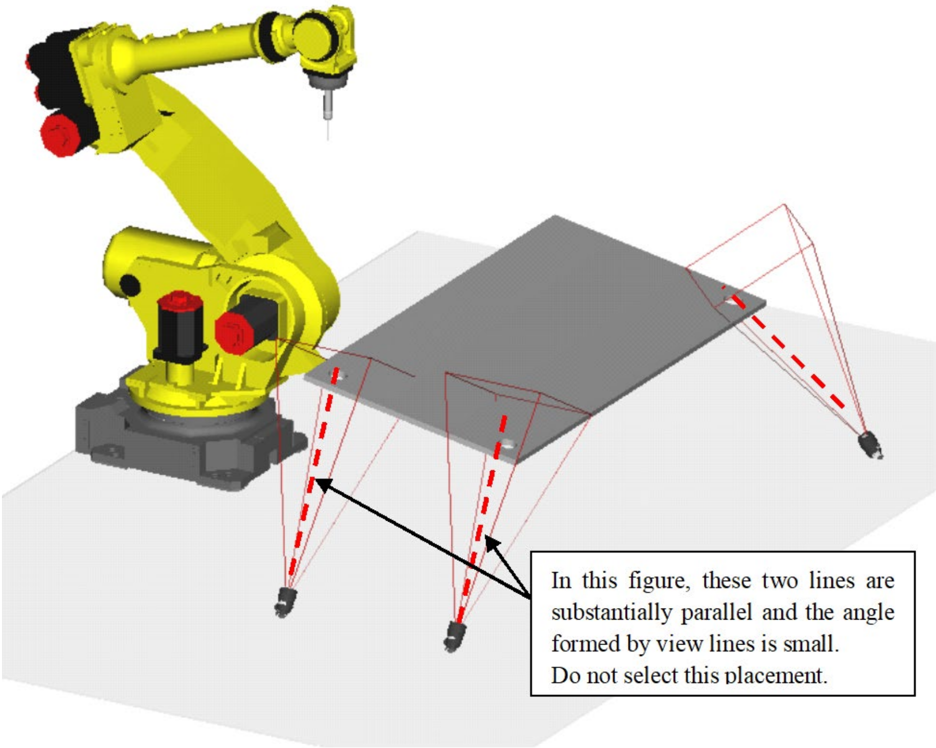
4.1 FEATURES AND NOTES

Features

- Three-dimensional compensation is made by measuring three points on a large workpiece that has the potential to move in three dimensions.
- Compensation is applied to all of six degrees of freedom for parallel displacement (X, Y, Z) and rotation (W, P, R) of the workpiece.
- The number of measurement points (number of camera views) is three and cannot be changed.
- The 3D Tri-View Vision Process has 'camera views' in a program as two-dimensional compensation based on multiple cameras. There are three camera views for measuring a total of three detection targets.
- During detection, a total of three view lines (one for each camera view) are measured. A triangle that takes the three detection targets as vertices and has known shape is applied to the three view lines to identify the position of each detection target on the corresponding view line and obtain the three-dimensional position and posture of the workpiece.
- Only fixed frame offset can be performed.
- Both a fixed camera and a robot mounted camera can be used.
- A robot mounted camera can measure a detection target while moving the position of the robot to the three locations. This capability is provided because the current position of a robot is considered in *i*RVision calculation processing when a target position calculation is made.

Notes

- The following conditions must be met when determining detection targets. (For a car body, the reference holes are suitable).
  - The exact relative position or distance between the three detection targets must be known. It should be obtained from a drawing.
  - The relative relation between the positions of the three detection targets and the work positions does not change individually.
  - Three detection targets can be set so that the whole workpiece can be covered.
  - The triangle having the three detection targets as its vertices is not too shallow.
  - The shapes of the detection targets are constant.
  - There is no portion having a similar shape near the detection targets.
- Determine the camera view so that the detection targets do not fall outside the camera view even when they deviate at the maximum. However, if the camera field of view is too wide, the required compensation accuracy may not be obtained.
- When the detection targets are detected, three view lines are measured. The cameras need to be placed so that any pair of view lines is not parallel and any angle formed by tow view lines is large to some extent (if possible, 60 degrees or more). If the angle formed by view lines is tool small, the required precision may not be obtained.



Angle formed by view lines

Preparation for drawings etc. about a workpiece

The 3D Tri-View Vision Process uses the distance between detection targets for calculation, so it is necessary to input the coordinates of detection targets of the workpiece in an arbitrary coordinate system. The coordinate system is not important because the relative distance between the targets is what is important. Typically the coordinates of the targets in the workpiece come from a drawing.

4.2 SETUP FOR FIXED FRAME OFFSET WITH FIXED CAMERA

Three fixed cameras measure three points of the workpiece.
Use the following setup procedure for fixed frame offset with fixed camera:

1. Camera Data Creation and Teaching

⇩

2. Vision process creation and teaching

⇩

3. Robot program creation and teaching

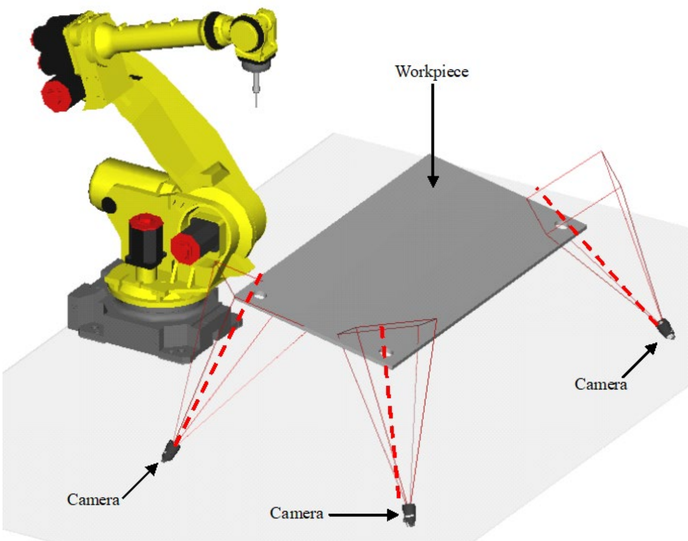
⇩

4. Robot Compensation Operation Check

When starting up a robot system that uses *i*RVision, perform all of the tasks described above. If the camera gets out of position or the camera is replaced, please perform camera calibration again using Section 1, 'Camera Data Creation and Teaching'. When a camera calibration has been already finished, in addition, a workpiece is changed or a kind of workpiece is added, perform '2 Vision process creation and teaching' and '3 Robot program creation and teaching'.

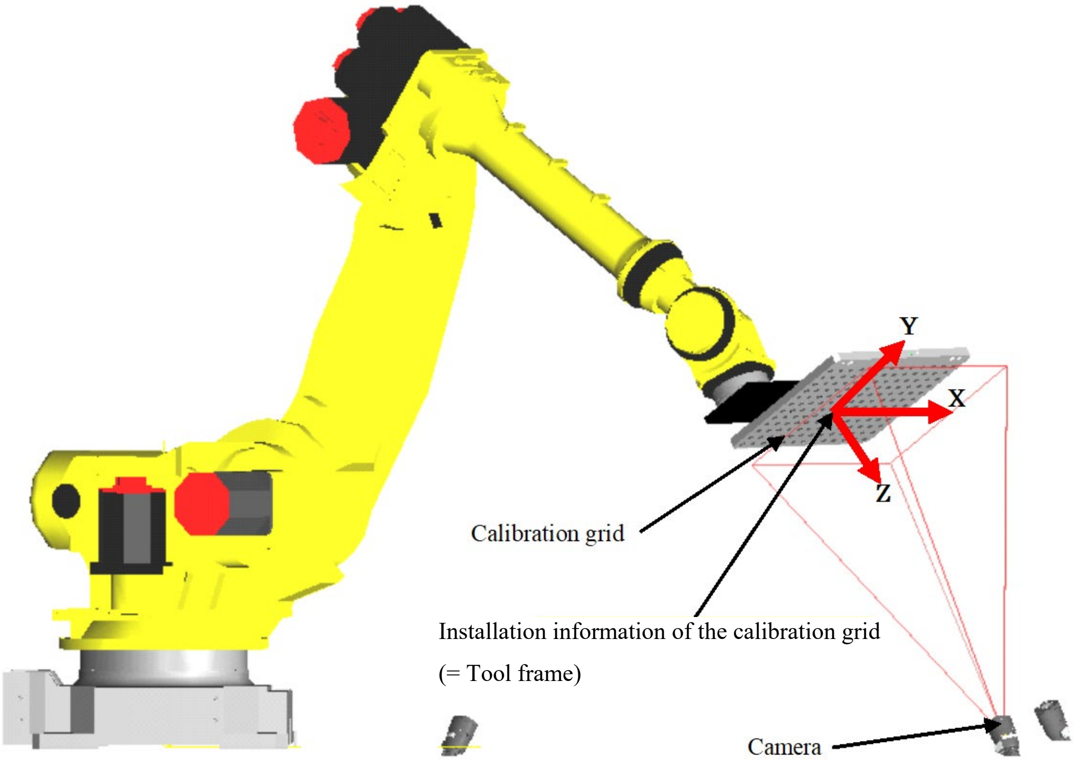
4.2.1 Camera Data Creation and Teaching

Create camera data and perform basic settings and calibration for the camera.
For the 3-D Tri-View Vision Process, create three sets of camera data and perform calibration for each camera. As an example, for the layout shown in the figure below, three sets of camera data are taught.



Example of a layout for creating camera data for each camera

For the 3-D Tri-View Vision Process, a convenient method is to attach a calibration grid to the robot hand and then calibrate, as shown in the figure below.



Installation example for Grid Pattern Calibration

For the setup method for Grid Pattern Calibration, refer to Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA".

Application frame setup

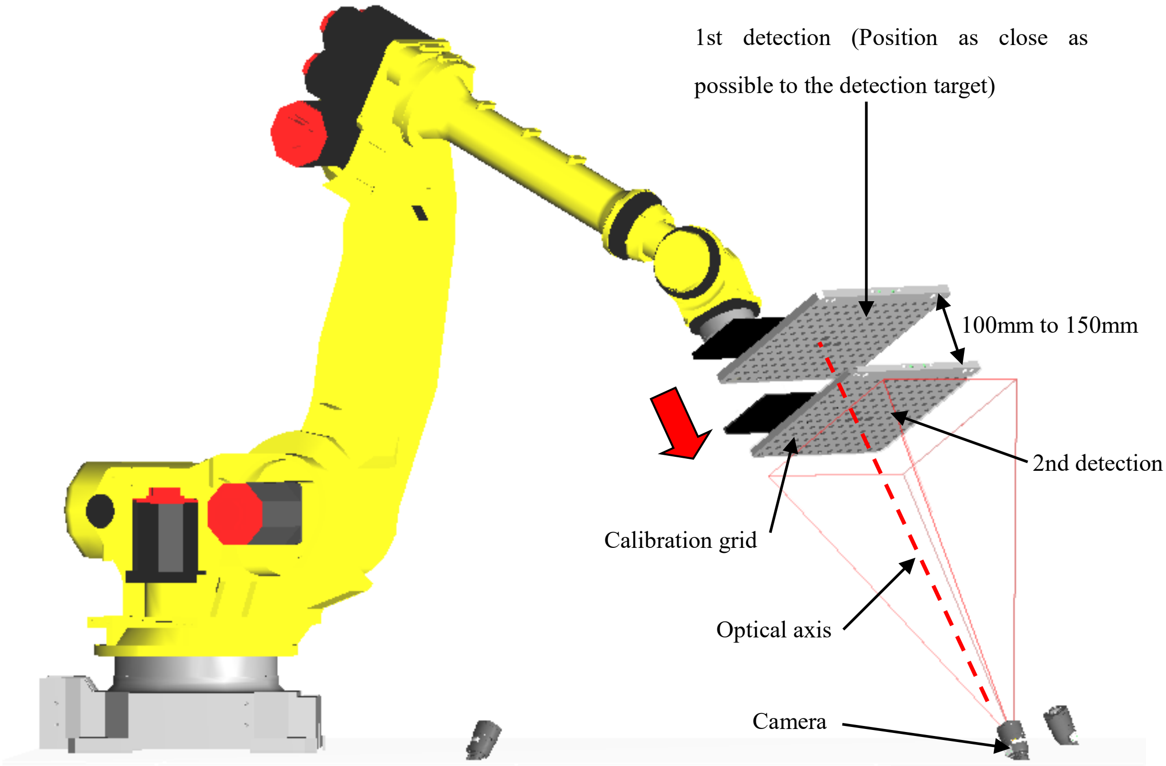
In the 3D Tri-View Vision Process, application frame has a role of a coordinate system used as a camera calibration, and a role of a coordinate system used for calculation of the offset data. So, the reference position and the found position are outputted as a position on the application frame in the 3D Tri-View Vision Process. Moreover, in the 3D Tri-View Vision Process, a workpiece is large in many cases. So, two or more robots may use a compensation data. In this case, set up an application frame on a plane which is a common for all robots, and use this user frame as an application frame.(Set the same application frame number for all robot).

Information setup for mounting the calibration grid

Install the calibration grid on the mounted robot. When set a calibration grid frame, it is recommended that use the Grid Frame Setting Function. Set a tool frame as the calibration grid frame.

Calibration data creation and teaching

Create three sets of camera data and perform calibration for each.
Perform the calibration for all cameras. Create three camera setup data files and three camera calibration data files. Note [Application frame] number must be the same in all calibration data used.
Perform two-plane calibration by moving the robot up and down as shown in the figure below. Perform detection by bringing calibration surface 1 as close as possible to the detection target. The up/down distance for two-plane calibration should be 100 to 150 mm. Detect the calibration grid at two different heights. Move the calibration grid along the optical axis of the camera.
Perform robot jog without changing the calibration grid posture.



Example of two plane calibration execution

4.2.2 Vision Process Creation and Teaching

Perform vision process creation and teaching.
The basic setting procedure for the vision process is the same as for [2-D Single-View Vision Process]. The part that is different is that three [Camera Views] are added. The camera views for each measurement position are named [Camera View 1], [Camera View 2] and [Camera View 3]. The snap tool and locator tools such as the GPM Locator Tool are placed under each camera view.
3-D Tri-View Vision Process teaching is performed using the following procedure.

1 Under [Camera View 1], select camera data and teach fundamental data.

⇩

2 Teach locator tools for [Camera View 1].

⇩

3 Select [Camera View 1] and click [SNAP] to snap an image.

⇩

4 Perform steps 1 to 3 for [Camera View 2] and [Camera View 3].

⇩

5 Select [Offset data Calculation Tool] and click [FIND] to find the workpiece.

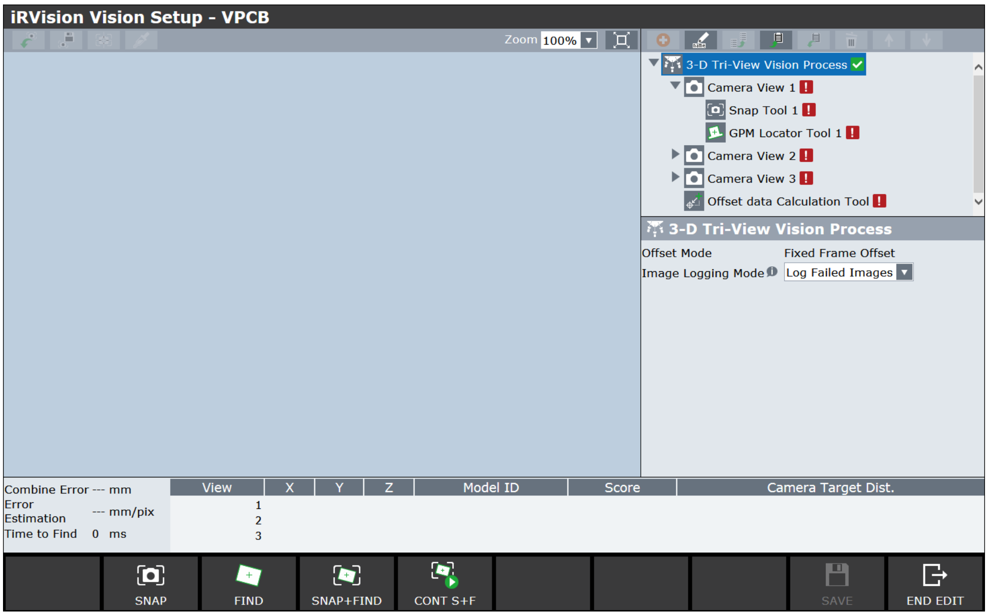
⇩

6 Set the reference position in [Offset data Calculation Tool].

4.2.2.1 Vision process creation

1 Create a vision process for [3-D Tri-View Vision Process].
For details on vision process creation, refer to the description of creating new vision data in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2 On the vision data list screen, if you select the created vision process and click [Edit], the vision data edit screen will appear.

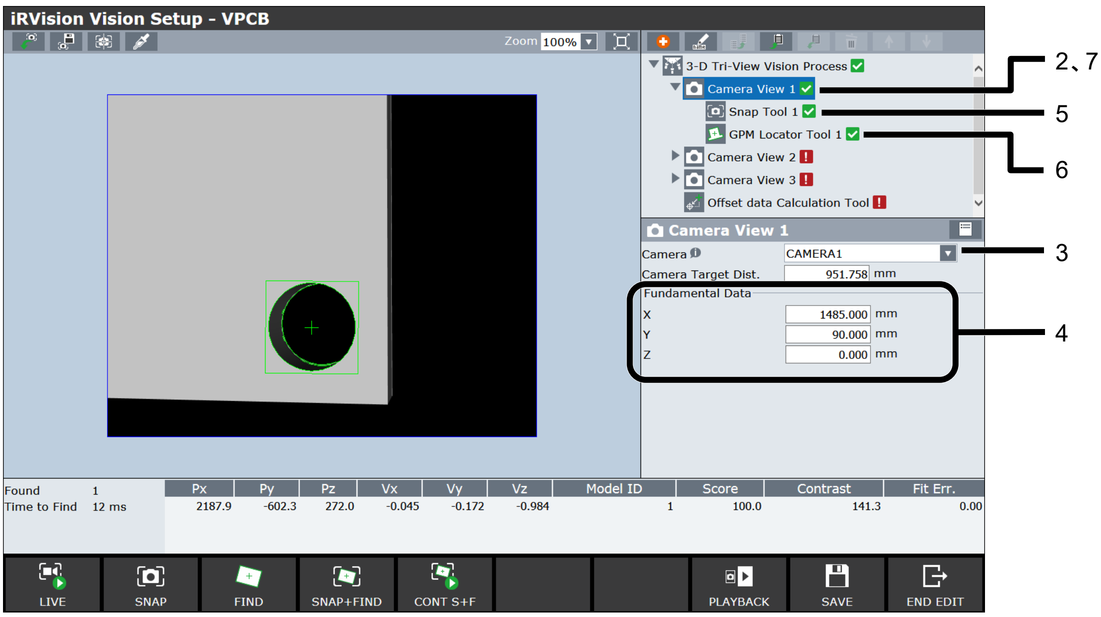


The offset mode for [3-D Tri-View Vision Process] supports only fixed frame offset.

4.2.2.2 Camera view teaching

Teach the snap tool and the locator tools such as GPM Locator Tool, for each camera view.

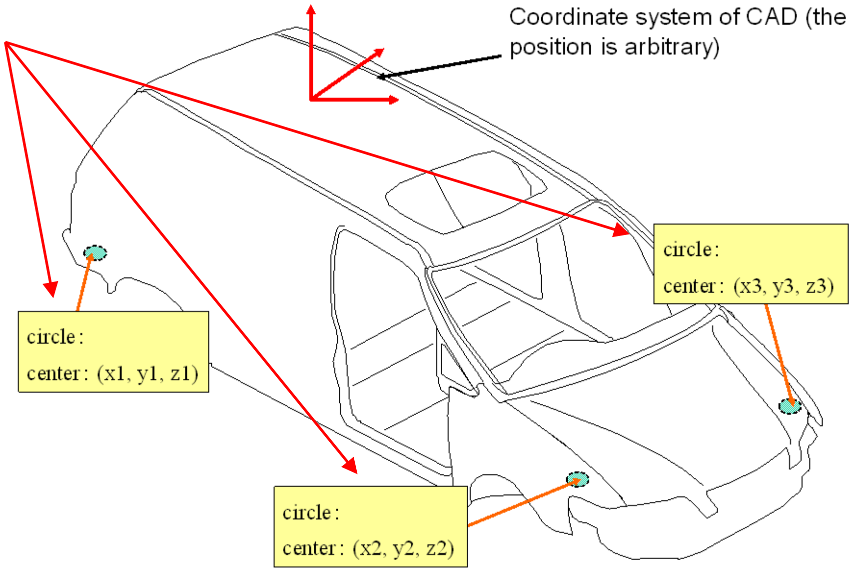
1 Put a workpiece in place.
2 Select [Camera View 1] from the tree view.



3 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 4.2.1, "Camera Data Creation and Teaching".

4 Enter the coordinates of the detection target in the [X], [Y] and [Z] field in [Fundamental Data] of [Application Frame] specified for camera calibration.
Enter an appropriate value as shown in the figure below.

- Example of entering fundamental data:
  This is an example of entering CAD data of the workpiece. Enter the coordinates of the detection target displayed in CAD as fundamental data.



Example of coordinates for the detection target

5 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap range and exposure time. For details, refer to the discription of Snap Tool in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

6 Select a locator tool from the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details on the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN ".

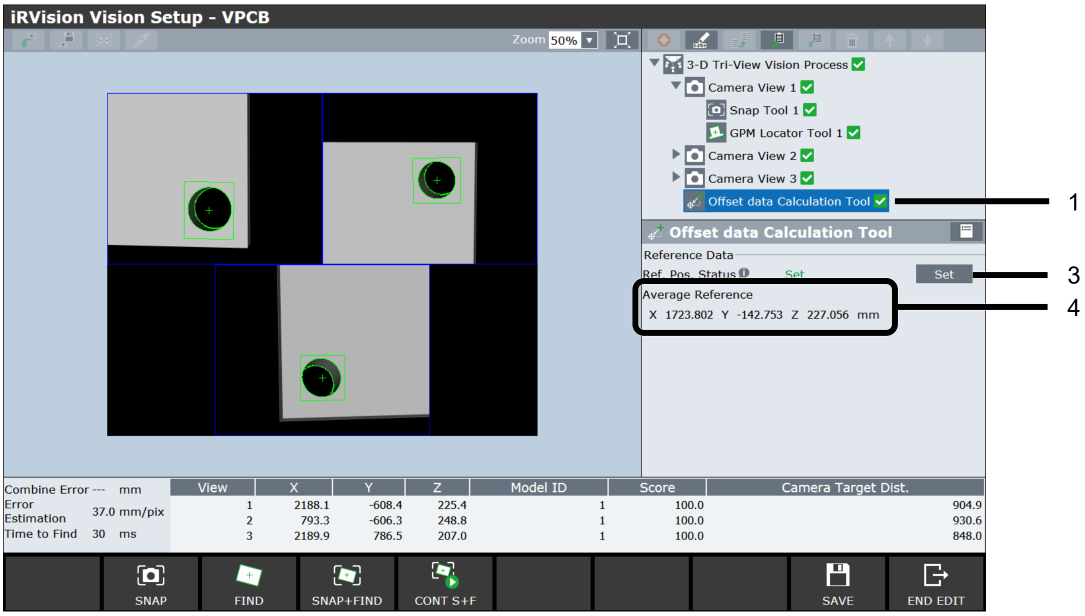
7 Select [Camera View 1] and click [SNAP] to snap an image of the workpiece.

8 When [Camera View 1] setup is complete, perform the setup in steps 2 to 7 for [Camera View 2] and [Camera View 3] in the same way.

4.2.2.3 Reference position setting

1 Select [Offset data Calculation Tool] from the tree view.
2 Click [FIND] to find the workpiece for all camera views.

> ⚠ **CAUTION**
> Do not move the workpiece until the reference position setting is complete.



3 Click the [Set] button for [Ref. Pos. Status].
4 [Ref. Pos. Status] will be [Set] and values will be entered for [Average Reference X], [Average Reference Y] and [Average Reference Z].
The values are the average reference of the workpiece, seen from the offset frame.
5 Click [Save] and click [End Edit].
6 Jog the robot and move it to the position for performing work on the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 4.2.3, "Robot Program Creation and Teaching". P[2] in line 11 is the position for performing work on the workpiece. Record the current robot position to P[2], and the reference position setting is complete.

4.2.3 Robot Program Creation and Teaching

In the sample program below, a vision process named [A] is used. Three targets of a workpiece are found. If there is only a fixed camera, it is not necessary to specify a camera view number for the [VISION RUN_FIND] command. For fixed frame offset, add the [VOFFSET, VR] instruction as an operation statement.

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  R[1:Notfound]=0
 4:  L P[1] 2000mm/sec FINE
 5:
 6:  VISION RUN_FIND 'A'
 7:  VISION GET_OFFSET 'A' VR[1] JMP LBL[100]
 8:
 9:  !Handling
10:  L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]
11:  L P[2] 500mm/sec FINE VOFFSET,VR[1]
12:  CALL HAND_CLOSE
13:  L P[2] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]
14:  !Handling
15:  JMP_LBL[900]
16:
17:  LBL[100]
18:  R[1:Notfound]=1
19:
20:  LBL[900]
```

Detect the position of the workpiece in the line 6 and obtain the offset result of the detected workpiece on line 7. Line 10 is the approach position to the workpiece. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move to the grasp position on line 11. Move to escape position after grasping the workpiece on line 13. When a fixed camera is used, one [VISION RUN_FIND] instruction measures all camera views prepared beforehand. When the images of all camera views have been snapped, the line after the [VISION RUN_FIND] instruction is executed.

4.2.4 Robot Compensation Operation Check

Check that three points of a workpiece can be detected and that the compensation can be performed correctly.

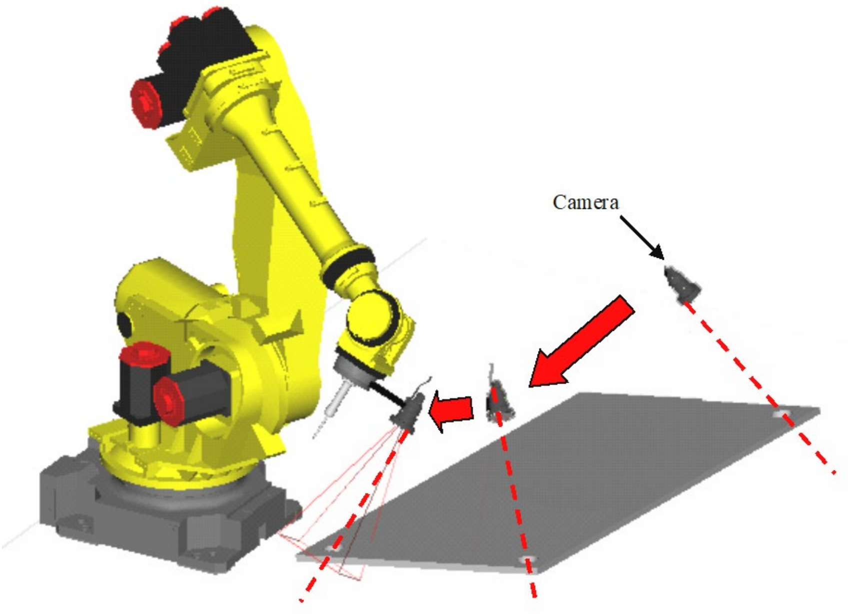
- At first, place the workpiece in the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting. Moreover, check the following things.
  - Check the relative relation location among three detection targets and workpiece itself does not have individual difference.
  - Check whether the each view positions with fundamental data are set correctly.
  - Check the calibration position. The first detection needs to be performed at position as close as possible to the detection target.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

✐Memo

If the workpiece cannot be found correctly due to a variation in the distances between measurement points, e.g., due to individual difference of workpieces, switch to the advanced mode in [Offset data Calculation Tool] and set [Combine Error Limit].

4.3 SETUP FOR FIXED FRAME OFFSET WITH ROBOT-MOUNTED CAMERA

An example of layout for fixed frame offset with robot-mounted camera is shown below. Three targets of a workpiece are measured by moving a camera.



Example of layout for fixed frame offset with robot-mounted camera

Use the following setup procedure:

1. Camera Data Creation and Teaching

⇩

2. Vision process creation and teaching

⇩

3. Robot program creation and teaching

⇩

4. Robot Compensation Operation Check

When begin a setup of a vision system newly, perform all the above procedures. When the position of the camera on the robot mechanical interface frame (the robot face plane) is shifted or cameras are exchanged, redo '1 Camera Data Creation and Teaching'.
When a camera calibration has been already finished, in addition, a workpiece is changed or a kind of workpiece is added, perform '2 Vision process creation and teaching' and '3 Robot program creation and teaching'.

4.3.1 Camera Data Creation and Teaching

Create camera data and perform basic settings and calibration for the camera.
If you are performing the 3-D Tri-View Vision Process with a robot-mounted camera, multiple locations on the workpiece are measured by a camera, but only one set of camera data is taught. For robot-mounted camera calibration, Grid Pattern Calibration is used. Robot-Generated Grid Calibration cannot be used for robot-mounted cameras. For the setup method for Grid Pattern Calibration, refer to Know-how Edition Section 2.2, "GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA".

Application frame setup

The application frame for the 3-D Tri-View Vision Process has a role as the user frame that is the basis for calibration and a role as the frame to be used for compensation calculations. Therefore, the reference position and found position for the 3-D Tri-View Vision Process are output as values in the application frame. Furthermore, in the 3-D Tri-View Vision Process, large workpieces such as car bodies are often handled, and there are times when compensation for multiple robots is performed with an offset. In such cases, set a common user frame on an arbitrary plane between the robots (set a common frame number), and select this as the application frame.

Information setup for mounting the calibration grid

It is recommended that you use the ‘Grid Frame Set’ for information setup for mounting the calibration grid. Set the calibration grid mounting position in the user frame.

4.3.2 Vision Process Creation and Teaching

Perform vision process creation and teaching.
The basic setting procedure for the vision process is the same as for [2-D Single-View Vision Process]. The part that is different is that 3 [Camera Views] are added. The camera views for each measurement position are named [Camera View 1], [Camera View 2] and [Camera View 3]. The snap tool and locator tools such as the GPM Locator Tool are placed under each camera view.
3-D Tri-View Vision Process teaching is performed using the following procedure.

1 Under [Camera View 1], select camera data and teach fundamental data.

2 Move the robot to the first measurement position and teach locator tools for [Camera View 1].

3 Select [Camera View 1] and click [SNAP] to snap an image.

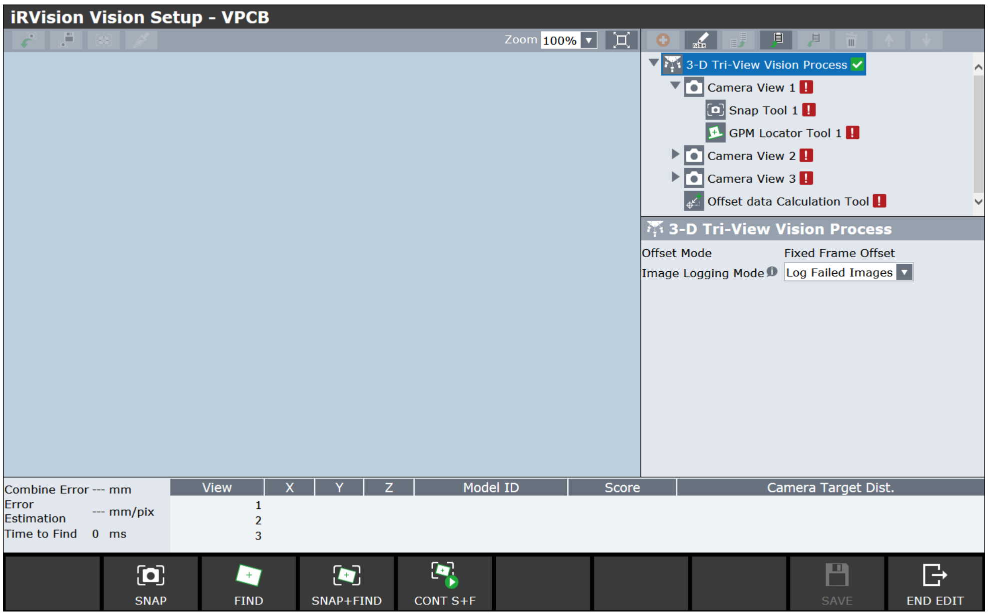
4 Perform steps 1 to 3 for [Camera View 2] and [Camera View 3].

5 Select [Offset data Calculation Tool] and click [FIND] to find the workpiece.

6 Set the reference position in [Offset data Calculation Tool].

4.3.2.1 Vision process creation

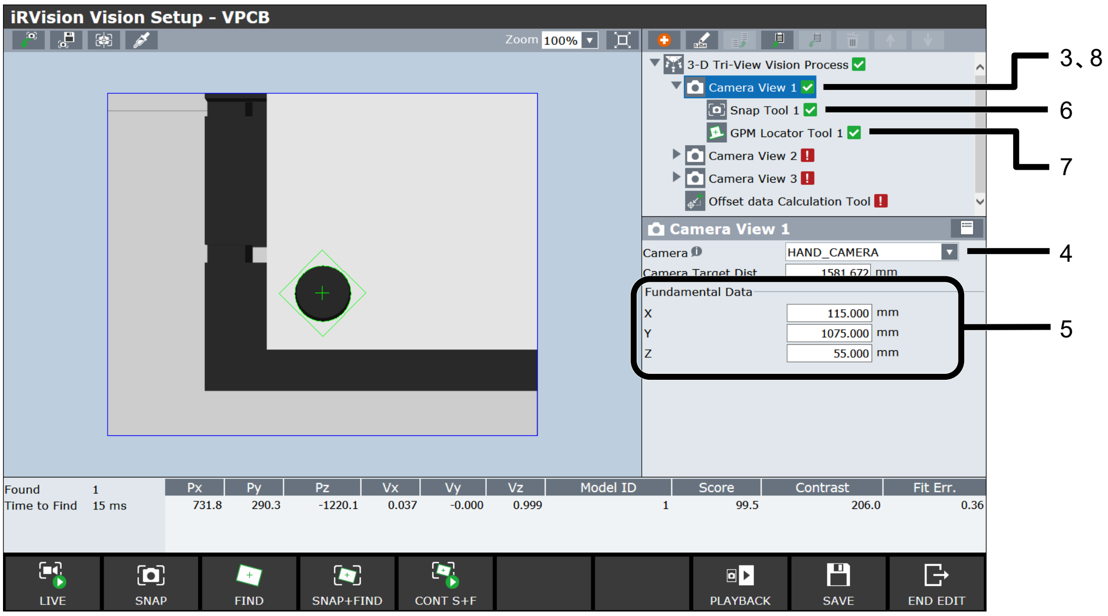
1. Create a vision process for [3-D Tri-View Vision Process].
   For details on vision process creation, refer to the description of creating new vision data in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".
2. On the vision data list screen, if you select the created vision process and click [Edit], the vision data edit screen will appear.



4.3.2.2 Camera view teaching

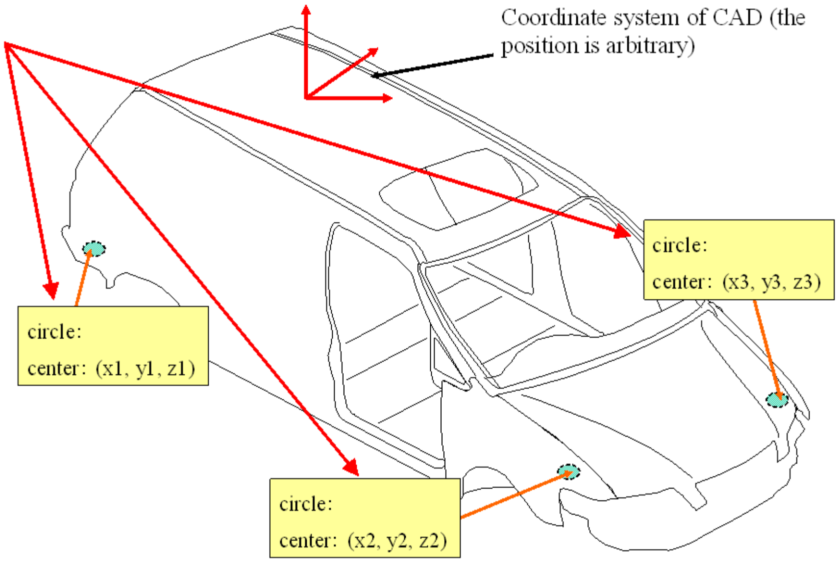
Teach the snap tool and the locator tools such as GPM Locator Tool, for each camera view.

1 Put a workpiece in place.
2 Jog the robot and move the camera to the first snap position.
Record this robot position as a snap position. For an example, refer to the sample program in Setup Edition Subsection 4.3.3, "Robot Program Creation and Teaching". P[1] in line 4 is the first snap position.
3 Select [Camera View 1] from the tree view.



4 From the [Camera] drop-down box, select the camera data to be used.
Select the camera data specified in Setup Edition Subsection 4.3.1, " Camera Data Creation and Teaching".
5 Enter the coordinates of the detection target as a fundamental data on any frame.

- **Example of entering fundamental data:**
  This is an example of entering CAD data of the workpiece. Enter the coordinates of the detection target displayed in CAD as fundamental data.



Example of coordinates for the detection target

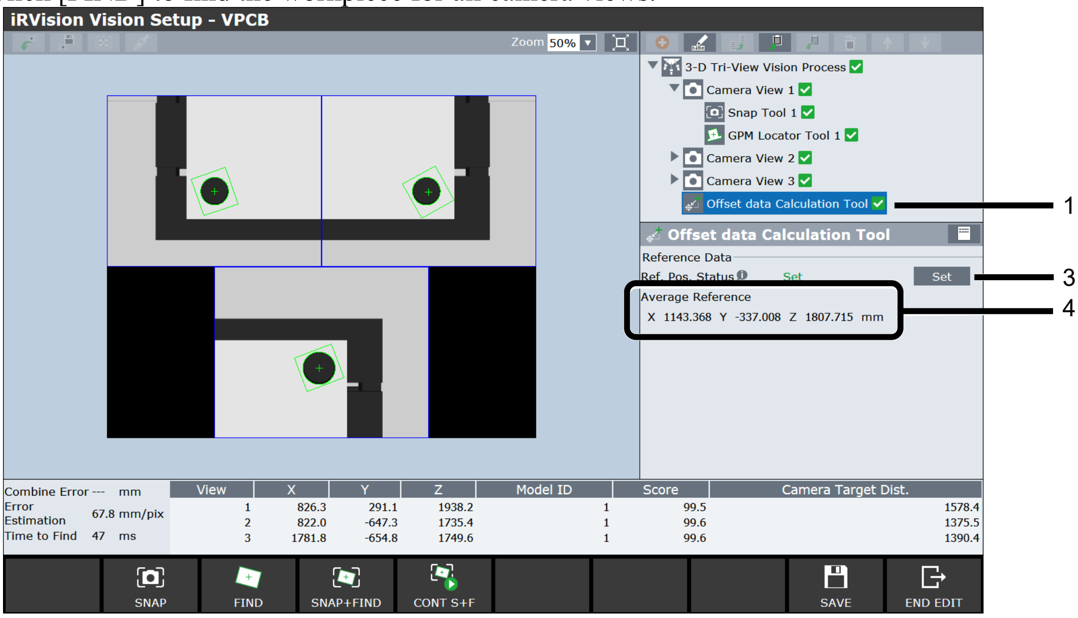
6 Set up the snap tool.
The snap tool is a tool that snaps images that are used to teach and find models. Set the snap conditions such as the snap range and exposure time. For details, refer to the description of Snap Tool in "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN".
7 Select a locator tool from the tree view and teach the model to use for detection.
By default, the GPM Locator Tool is set as the locator tool. For details on the GPM Locator Tool and other command tools, refer to the description of Command Tools in "*i*RVision MANUAL (Reference) B-83914EN".
8 Select [Camera View 1] and click [SNAP] to snap an image of the workpiece.
9 When [Camera View 1] setup is complete, perform the setup in steps 2 to 8 for [Camera View 2] and [Camera View 3] in the same way.

4.3.2.3 Reference position setting

1 Select [Offset data Calculation Tool] from the tree view.

> ⚠ **CAUTION**
> Regarding the following steps, do not click [SNAP] on the offset data calculation tool until the reference position setting is complete. Otherwise, images are snapped at the current position for all camera views and prevent you from setting the reference position. Also, do not move the workpiece.

2 Click [FIND] to find the workpiece for all camera views.



3 Click the [Set] button for [Ref. Pos. Status].

4 [Ref. Pos. Status] will be [Set] and values will be entered for [Average Reference X], [Average Reference Y] and [Average Reference Z].
The values are the average reference of the workpiece, seen from the offset frame.

5 Click [Save] and click [End Edit].

6 Jog the robot and move it to the position for performing work on the workpiece (e.g. gripping it).
For an example, refer to the sample program in Setup Edition Subsection 4.3.3, "Robot Program Creation and Teaching". P[4] in line 17 is the position for performing work on the workpiece. Record the current robot position to P[4], and the reference position setting is complete.

4.3.3 Robot Program Creation and Teaching

In the sample program below, a vision process named [A] is used. three targets of a workpiece are found by moving the robot-mounted camera. Vision process A has three camera views which have different view positions of robot mounted cameras, so that each camera view number is added to the [VISION RUN_FIND] instruction. For fixed frame offset, add the [VOFFSET, VR] instruction as an operation statement.

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  R[1:Notfound]=0
 4:  L P[1] 2000mm/sec FINE
 5:  WAIT R[1]
 6:  VISION RUN_FIND 'A' CAMERA_VIEW[1]
 7:  L P[2] 2000mm/sec FINE
 8:  WAIT R[1]
 9:  VISION RUN_FIND 'A' CAMERA_VIEW[2]
10:  L P[3] 2000mm/sec FINE
11:  WAIT R[1]
12:  VISION RUN_FIND 'A' CAMERA_VIEW[3]
13:  VISION GET_OFFSET 'A' VR[1] JMP LBL[100]
14:
15:  !Handling
16:  L P[4] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]
17:  L P[4] 500mm/sec FINE VOFFSET,VR[1]
18:  CALL HAND_CLOSE
19:  L P[4] 2000mm/sec CNT100 VOFFSET,VR[1] Tool_Offset,PR[1]
20:  !Handling
21:  JMP_LBL[900]
22:
23:  LBL[100]
24:  R[1:Notfound]=1
25:
26:  LBL[900]
```

Move to the position of camera view 1 to snap on line 4. Execute “WAIT” instruction to remove the possible vibration of a camera on line 5. Execute camera view 1 of vision process “A” with the vision run_find instruction on line 6. When the camera image has been snapped, the line after the [VISION RUN_FIND] instruction is executed. Move to the position of camera view 2 to snap on line 7. Move to the position of camera view 3 to snap on line 10. Obtain the offset of the detected workpiece on line 13. Move to the approach position above the workpiece on line 16. Since this is the approach position to the workpiece, add the tool offset command so that the robot position is offset by PR[1] from the workpiece (for example, above the workpiece). Move to the grasp position on line 17. Move to the escape position after grasping the workpiece on line 18.

4.3.4 Robot Compensation Operation Check

Check that three points of a workpiece can be detected and that the compensation can be performed correctly.

- At first, place the workpiece on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting. Moreover, check the following things.
  - Check the relative relation location among the three detection targets and the workpiece itself does not have individual difference.
  - Check whether the each view positions with fundamental data are set correctly.

- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

Memo

If the workpiece cannot be found correctly due to a variation in the distances between measurement points, e.g., due to individual difference of workpieces, switch to the advanced mode in [Offset data Calculation Tool] and set [Combine Error Limit].

Know-How

1 FRAME SETTING

This chapter explains the setting method for the user frame and tool frame.
In *i*RVision, the following frames are used.

- World frame
  The frame that is defined in the robot from the start. A specified location is defined for each model of robot. It cannot be changed.
- User frame
  A frame that is defined by a user. It is expressed using a relative position from the world frame. It will be the same as the world frame when it is not set.
- Tool frame
  A frame that shows the tool center point (TCP) and orientation of a tool. It needs to be set up in accordance with each tool.

In *i*RVision, the above frames need to be setup in [Application Frame] or [Offset Frame].
For details on the general method for frame setting, refer to the description of setting coordinate systems in "OPERATOR’S MANUAL (Basic Function) B-83284EN".
There are two methods for frame setting. Refer to the following for each setting method.

- Setting with a pointer tool
  For the setting method, refer to Know-how Edition Section 1.1, "FRAME SETTING WITH A POINTER TOOL".
- Setting with the grid frame setting function
  For the setting method, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION".

1.1 FRAME SETTING WITH A POINTER TOOL

This is a method for setting a user frame or tool frame by physically performing touch-up with a pointer tool.
This section explains a user frame and tool frame with the following configuration.

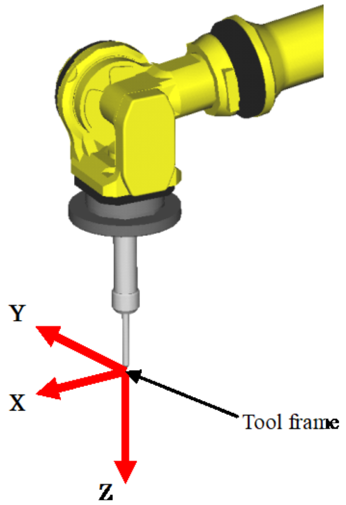
- For user frame setting, refer to Know-how Edition Subsection 1.1.1, "User Frame Setting".
- For tool frame setting, refer to Know-how Edition Subsection 1.1.2, "Tool Frame Setting".

1.1.1 User Frame Setting

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

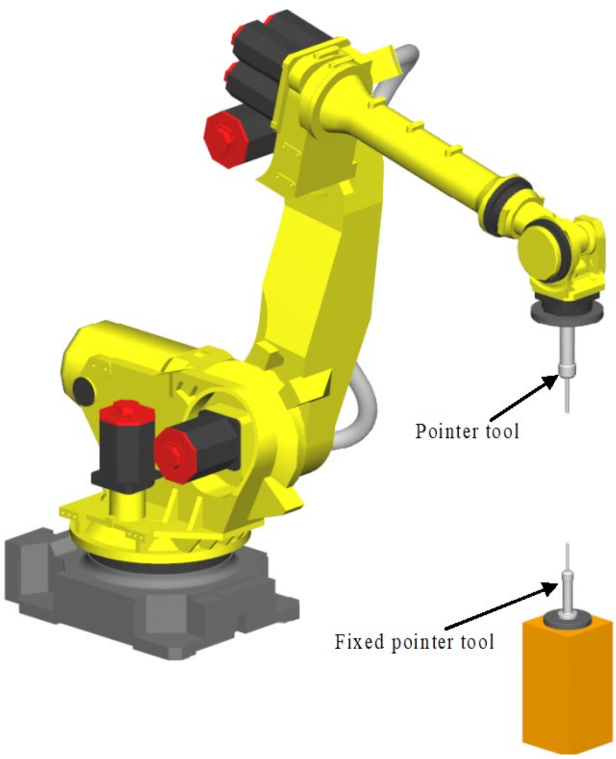
1.1.1.1 TCP set up

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



Pointer tool and tool frame

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

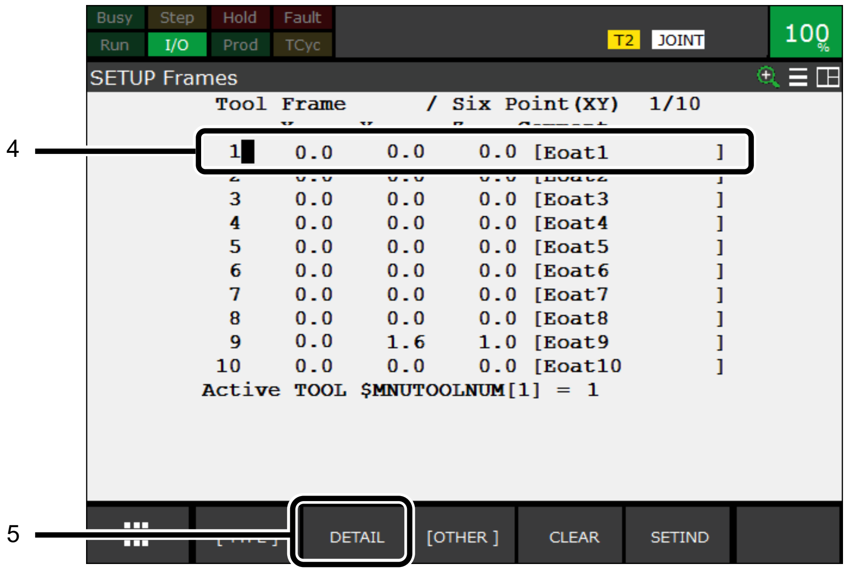


Example of a layout for pointer tool and fixed pointer tool

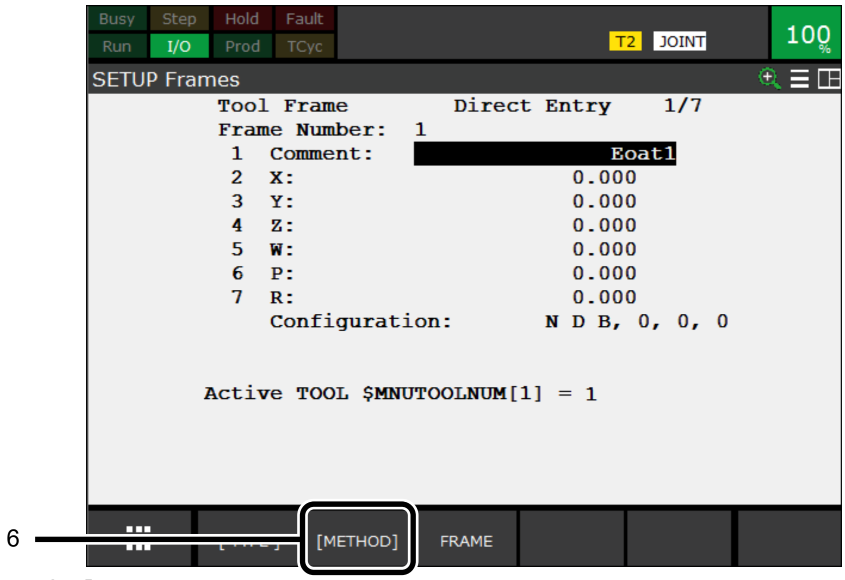
Three Point Method

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

1 On the teach pendant, after selecting the [MENU] key → [Setup], place the cursor over [Frame] and press the [ENTER] key.
2 Press F3 [Frame].
3 Place the cursor over [Tool] and press the [ENTER] key.
The list screen for tool frames will appear.

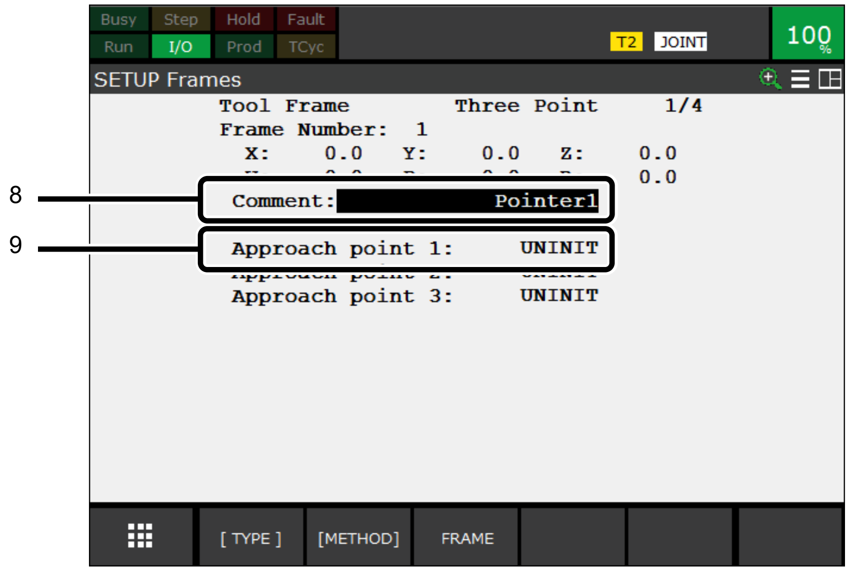


4 Place the cursor over the line of the tool frame number to set.
5 Press F2 [DETAIL].
The setup screen for the tool frame for the selected frame number will appear.

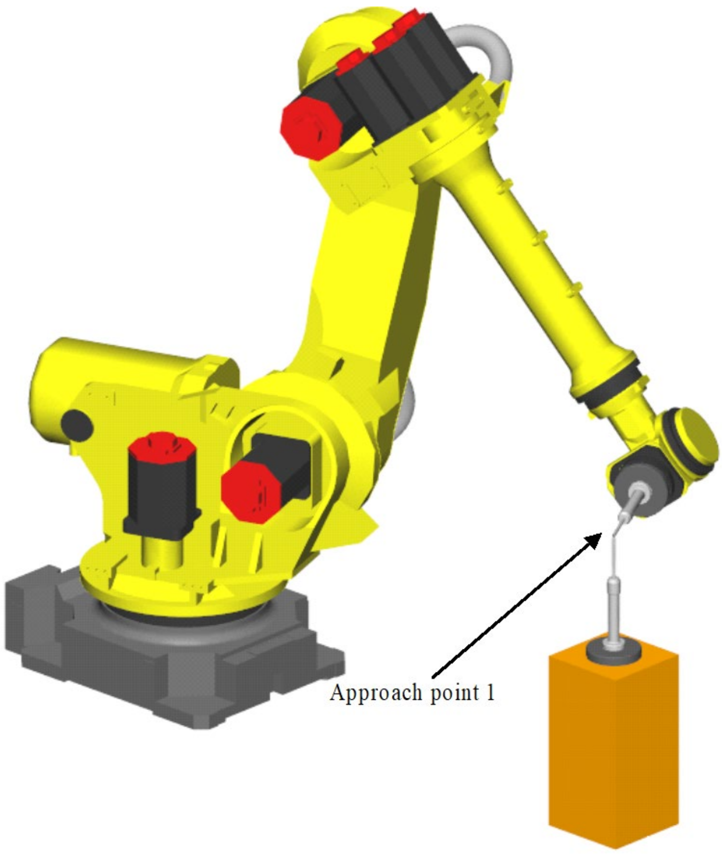


6 Press F2 [METHOD].

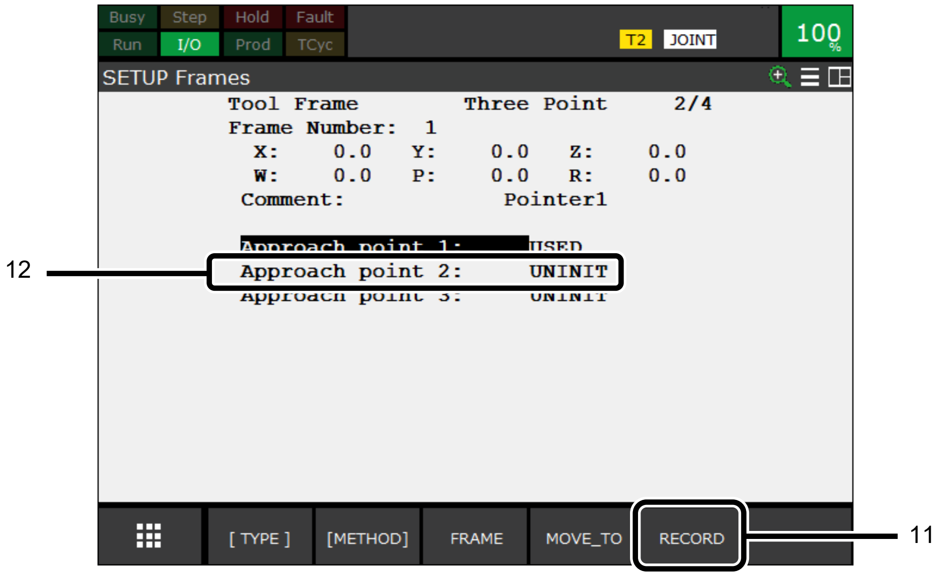
7 Place the cursor over [Three Point] and press the [ENTER] key.
A screen for tool frame setting using the three point teaching method will appear.



8 Enter a comment in the [Comment] field as required.
A comment to distinguish this frame from other frames is recommended.
9 Place the cursor over [Approach point 1].
10 Jog the robot and touch up the fixed pointer tool pin with the robot pointer tool pin.



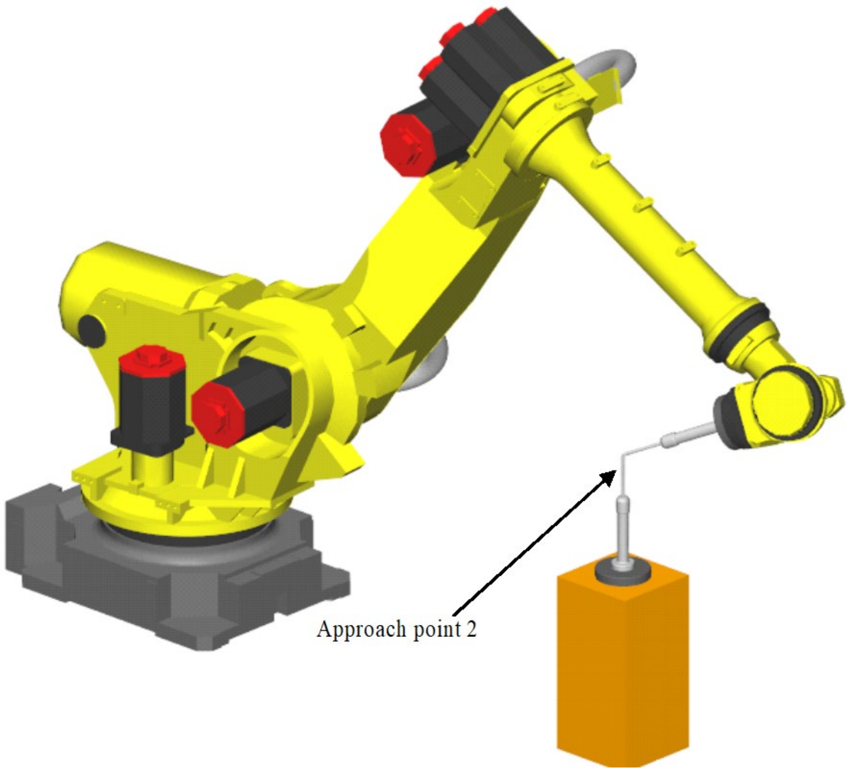
Touch-up of approach point 1



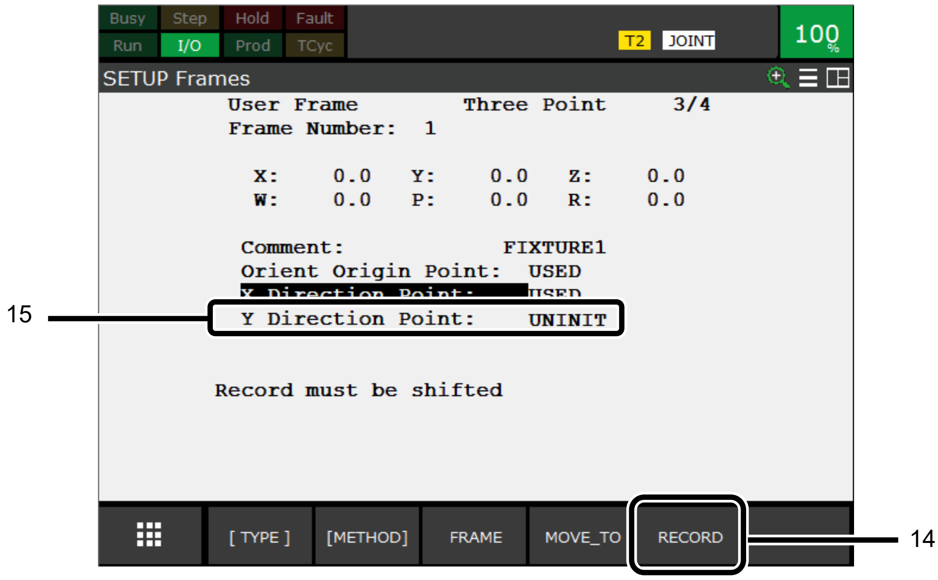
11 While holding down the [SHIFT] key, press F5 [RECORD].
The current value's data will be input as approach point 1.
For the taught [Approach point 1], [Used] will be displayed.

12 Place the cursor over [Approach point 2].

13 Jog the robot and touch up the fixed pointer tool pin with the robot pointer tool pin.
Touch up the same point as the reference point 1. However, change the robot attitude from that of the reference point 1.



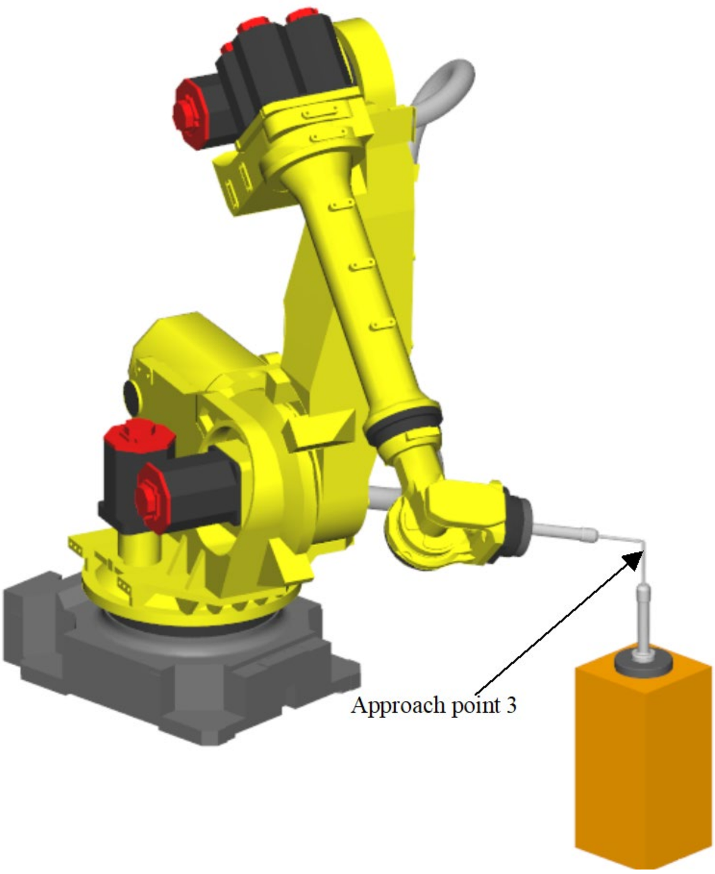
Touch-up of approach point 2



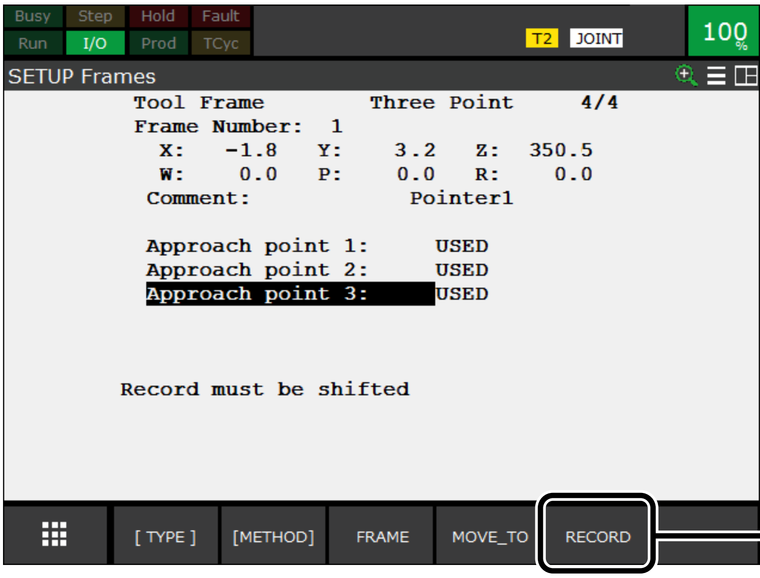
14 While holding down the [SHIFT] key, press F5 [RECORD].
The current value's data will be input as approach point 2.
For the taught [Approach point 2], [Used] will be displayed.

15 Place the cursor over [Approach point 3].

16 Jog the robot and perform touch-up of the fixed pointer tool with a pointer tool.
Perform touch-up of the same point as for [approach point 1]and [approach point 2]. However, make the orientation of the robot different from that for approach point 1 and approach point 2.



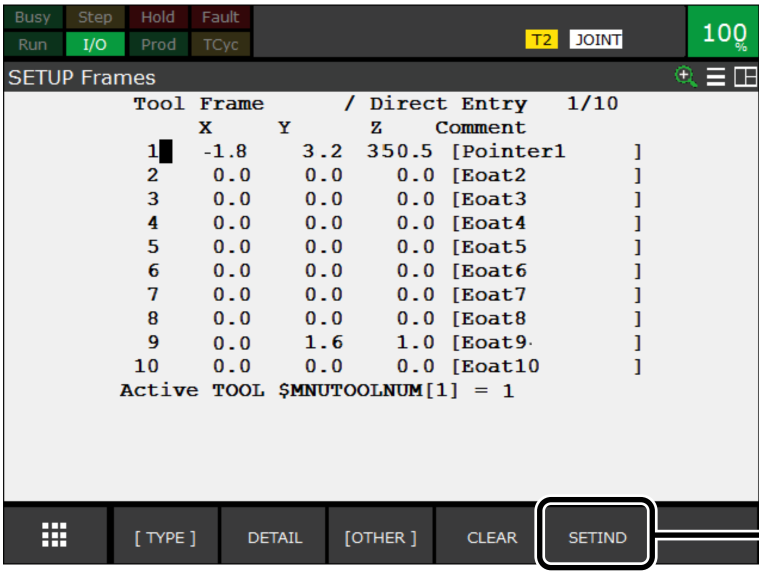
Touch-up of approach point 3



17

17 While holding down the [SHIFT] key, press F5 [RECORD].
The current value's data will be input as approach point 3.
When all the approach points are taught, [Used] will be displayed. The tool frame will be set.

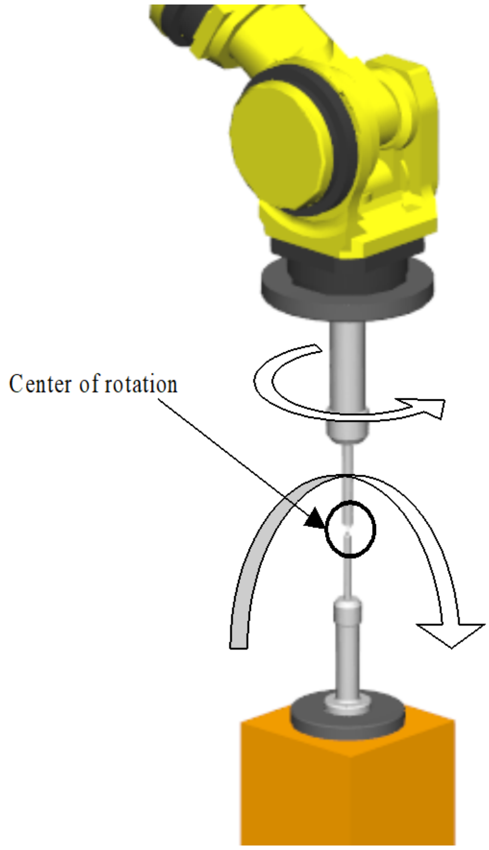
18 Press the [PREV] key.
The list screen for tool frames will appear.



19

19 Check that the TCP has been set correctly. Press F5 [SETIND] and enter the tool frame number.
The tool frame that has been set will be set as the currently enabled tool frame.

20 Operate the robot by jog operation to move its pointer tool close to the tip of the fixed pointer tool.



Check by moving the pointer tool close to the tip of the fixed pointer tool

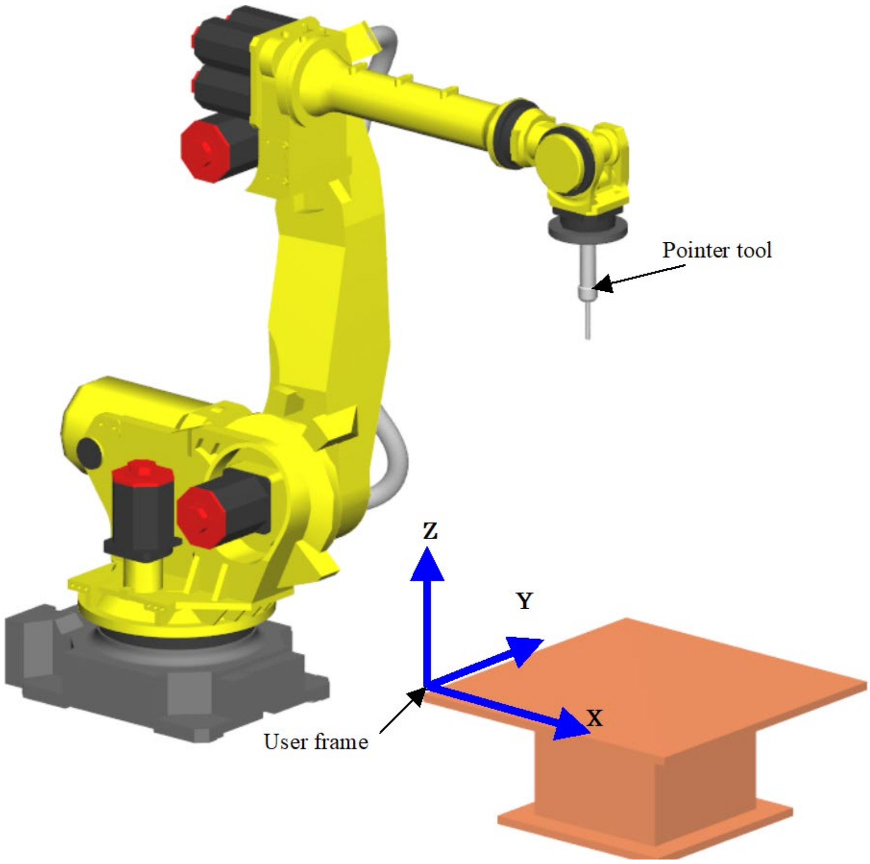
21 Operate the robot by jog operation around the tool frame, and change the orientation of the tool (w, p, r). If the TCP is accurate, the tip of the pointer tool will always point toward the tip of the fixed pointer tool.

1.1.1.2 Setting method types and procedures

To set an user frame, there are three methods that are "Three point method" , "Four point method" and "Direct list method". When use the "Three point method" or "Four point method" , use the pointer tool that is set in the Setup Edition Subsection 1.1.1.1 "TCP set up". Moreover, the accuracy of user frame setting becomes better as the distance of each taught points is far. When set the calibration grid frame, the distance of each taught points by using "Four point method" become longer than using the "Three point method". When set the calibration grid frame, the "Four point method" is recommended. The "Three point method" and "Four point method" is explained as shown below.

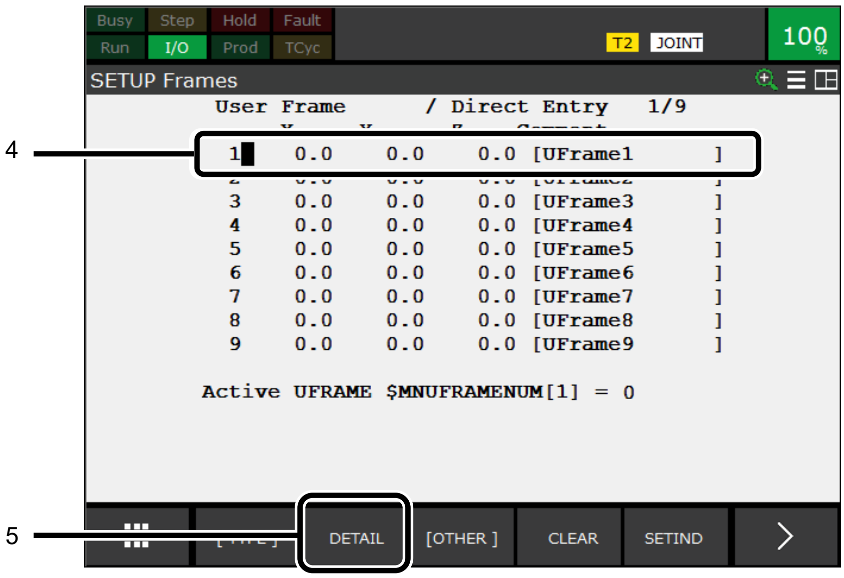
Three point method

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



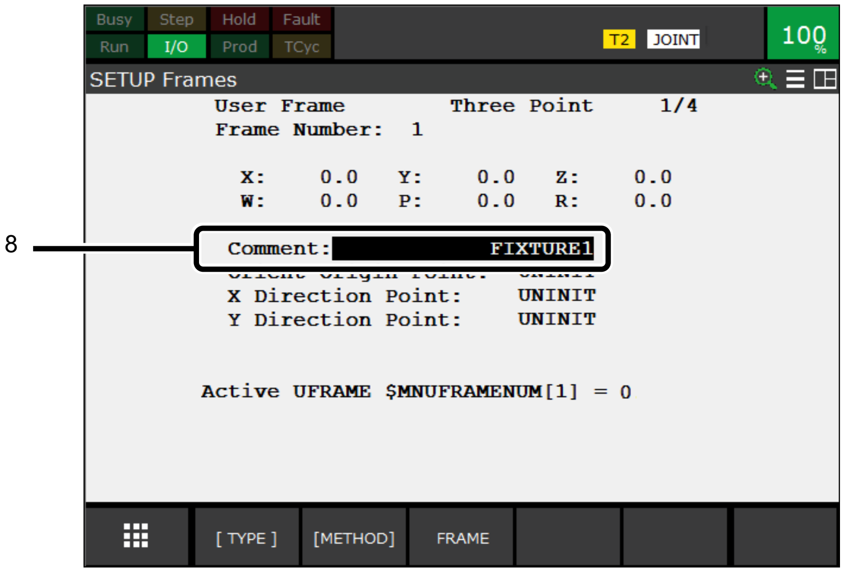
Example for setting a user frame that is parallel with a work table plane

1 On the teach pendant, after selecting the [MENU] key → [Setup], place the cursor over [Frame] and select pressing the [ENTER] key.
2 Select and press F3 [Frame].
3 Place the cursor over [User] and press the [ENTER] key.
The following list screen for user frames will appear.

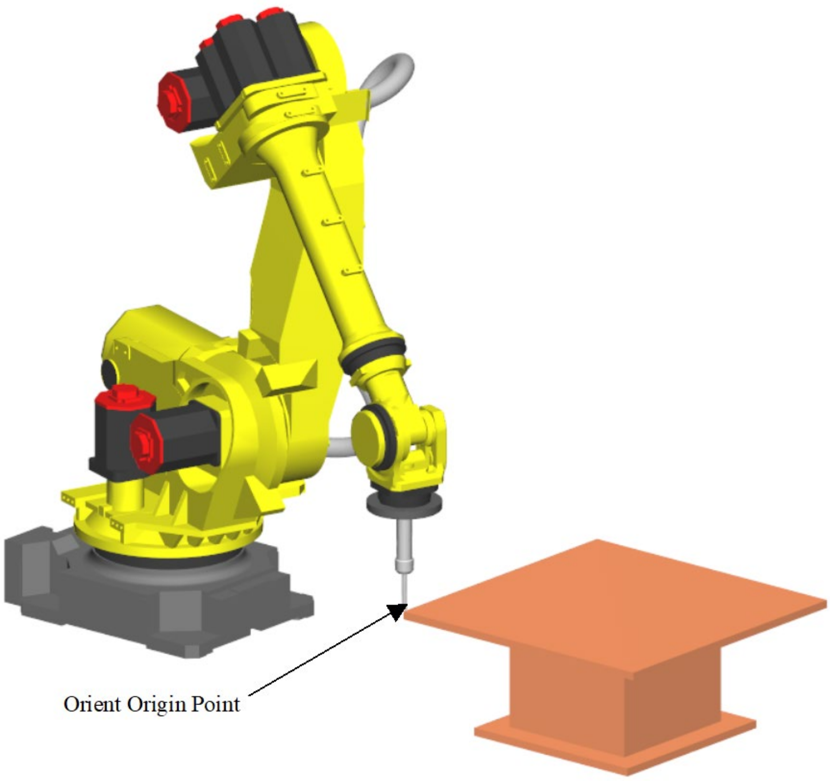


4 Place the cursor over the line number of the frame to be set.
5 Press F2 [DETAIL].
SETUP Frames screen for the selected frame will appear.

6 Press F2 [METHOD].
7 Place the cursor over [Three Point] and press the [ENTER] key.
A screen for user frame setting using the three point teaching method will appear.

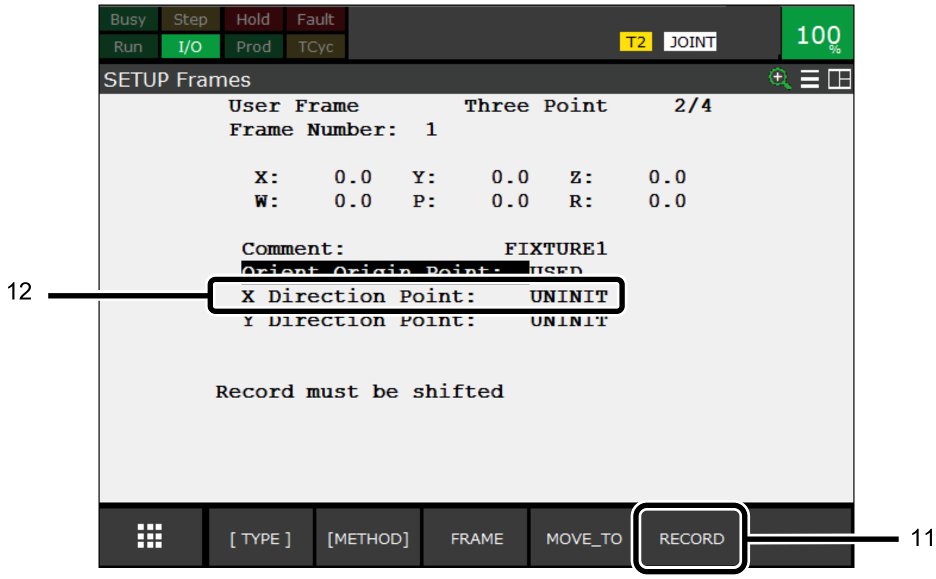


8 Enter a comment in the [Comment] field as required.
A comment to distinguish this frame from other frames is recommended.
9 Place the cursor over [Orient Origin Point].
10 Jog the robot and touch up the origin of the frame with the pointer tool pin.

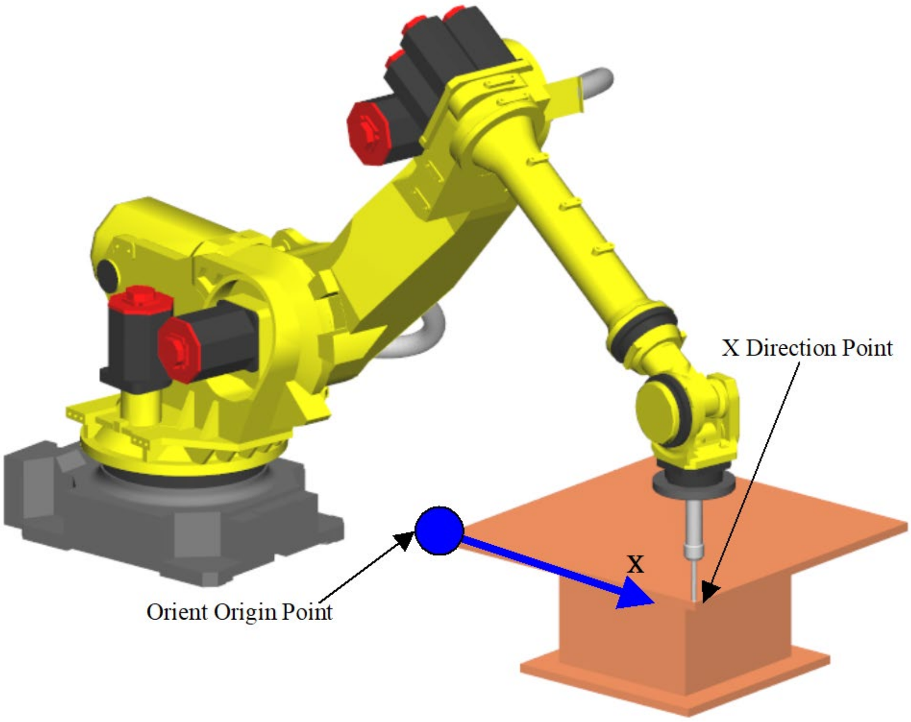


Touch-up of orient origin point

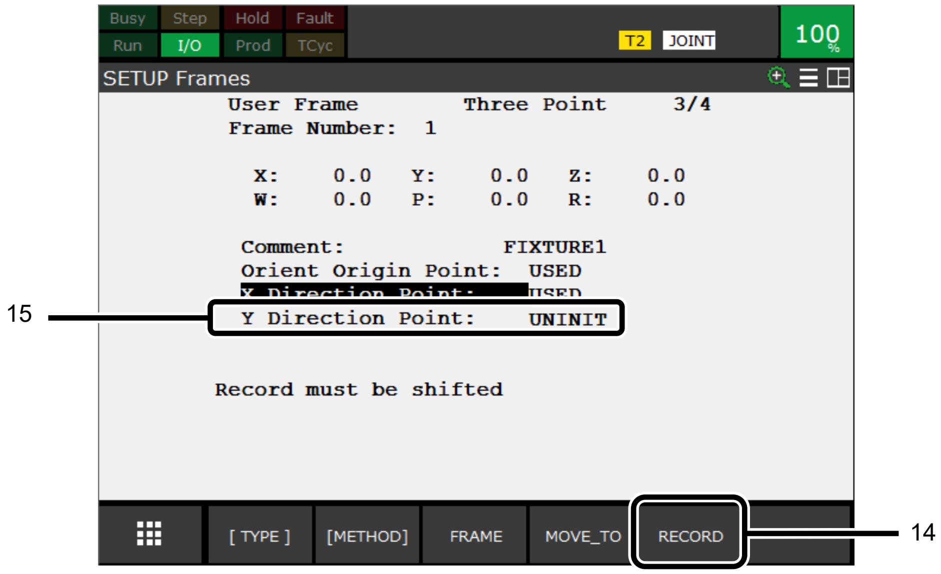
11 While holding down the [SHIFT] key, press F5 [RECORD].
The current position data will be recorded as the orient origin of the frame.
[USED] will be shown for the taught [Orient Origin Point].



12 Place the cursor over [X Direction Point].
13 Jog the robot and touch up the X direction point with the pointer tool.
A line drawn between the orient origin point and the touched up X direction point will be the X-axis of the frame.



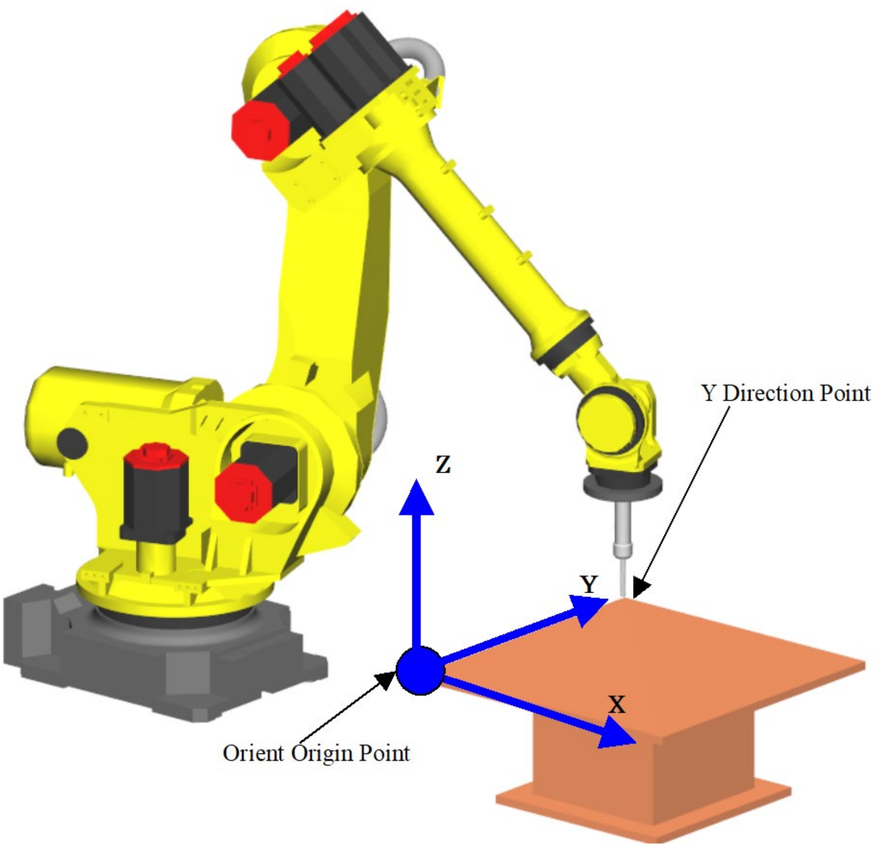
Touch-up of X direction point



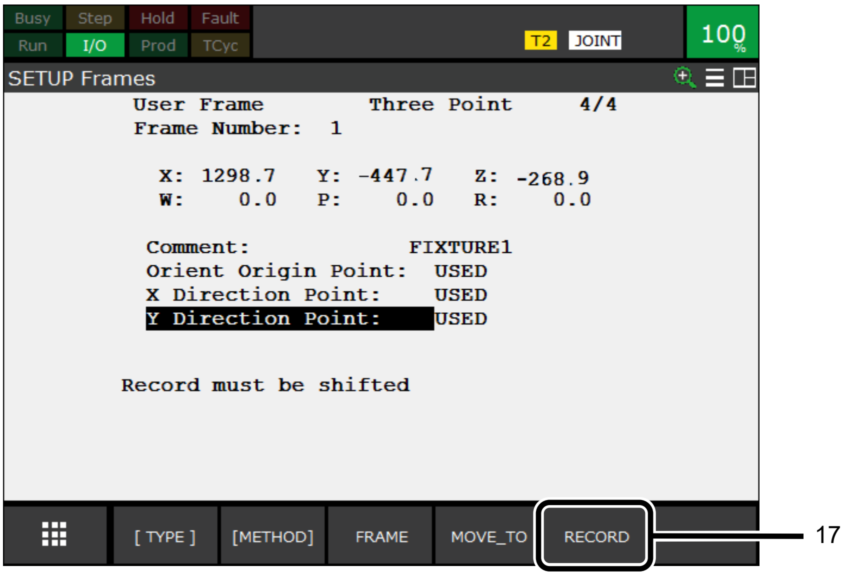
14 While holding down the [SHIFT] key, press F5 [RECORD].
The current position data will be recorded as the X direction point.
[USED] will be shown for the taught [X Direction Origin Point].

15 Place the cursor over [Y Direction Point].

16 Jog the robot and touch up the Y direction point with the pointer tool.
Touching up the Y-axis direction will determine the X and Y plane of the frame.

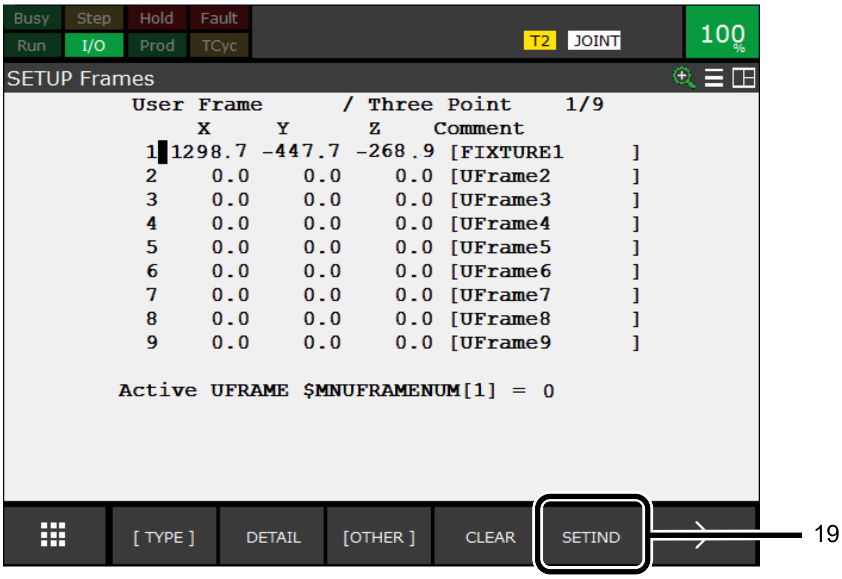


Touch-up of Y direction point



17 While holding down the [SHIFT] key, press F5 [RECORD].
When all the touch-up points are taught, [Used] will be displayed. The user frame will be set.

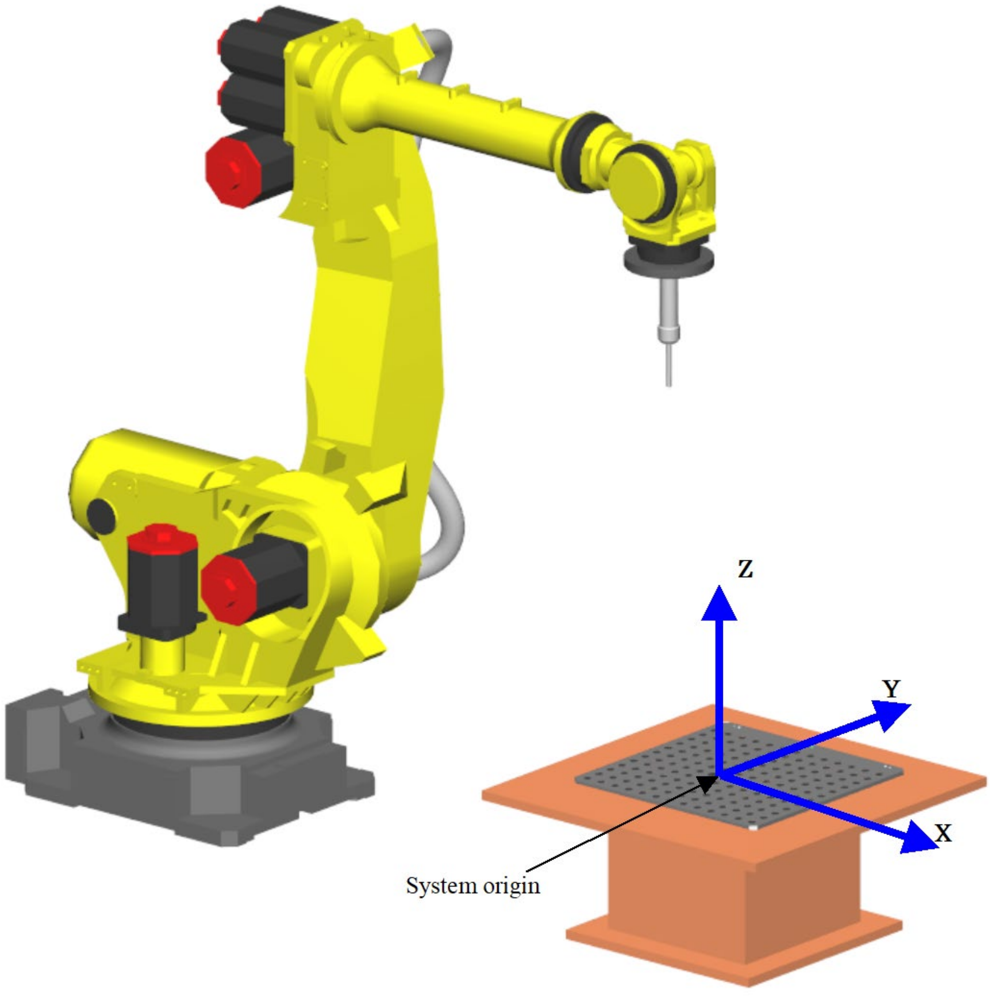
18 Press the [PREV] key.
The User Frame list screen will appear.



19 Press F5 [SETIND] and enter a frame number.
The user frame that has been set will be set as the currently enabled user frame.

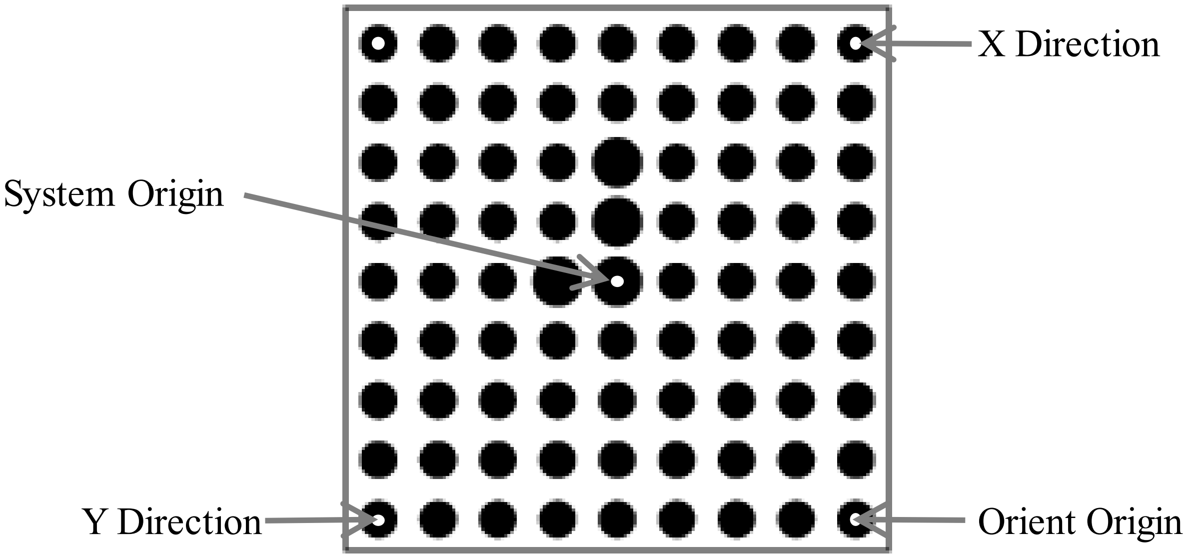
Four point method

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



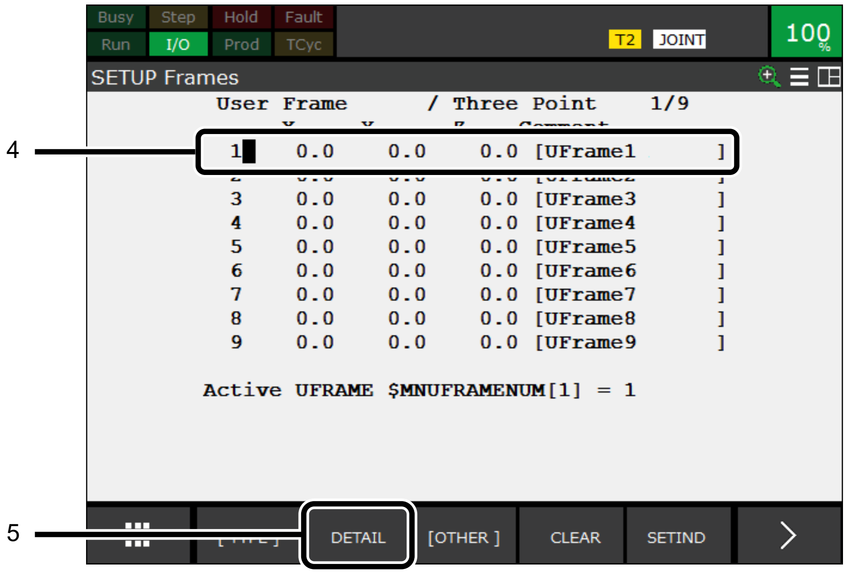
Example of setting a user frame on a fixed calibration grid

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

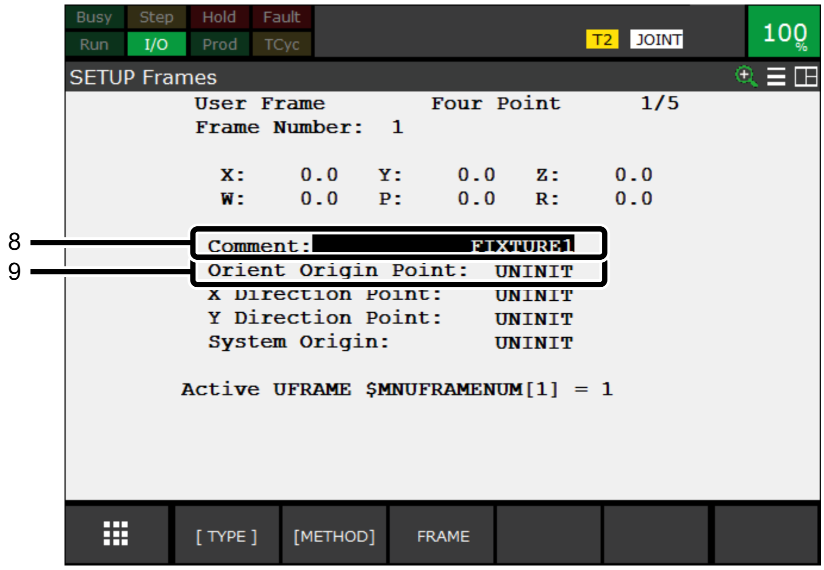


Four point teaching method touch-up points for a calibration grid

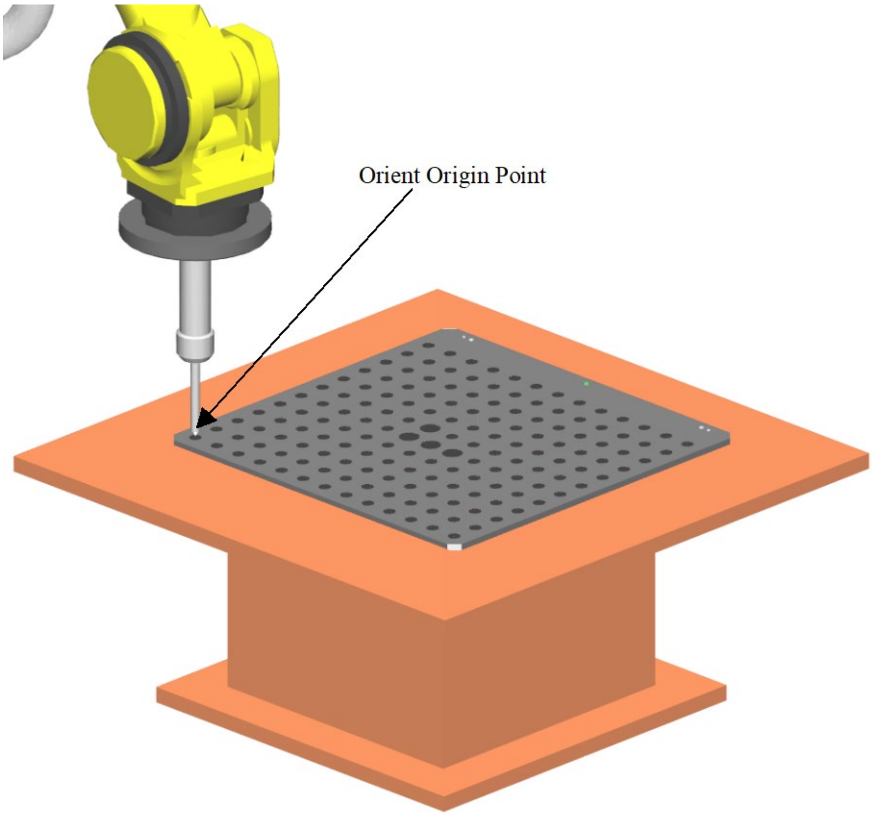
1 On the teach pendant, after selecting the [MENU] key → [Setup], place the cursor over [Frame] and press the [ENTER] key.
2 Press F3 [OTHER].
3 Place the cursor over [User] and press the [ENTER] key.
The list screen for user frames will appear.

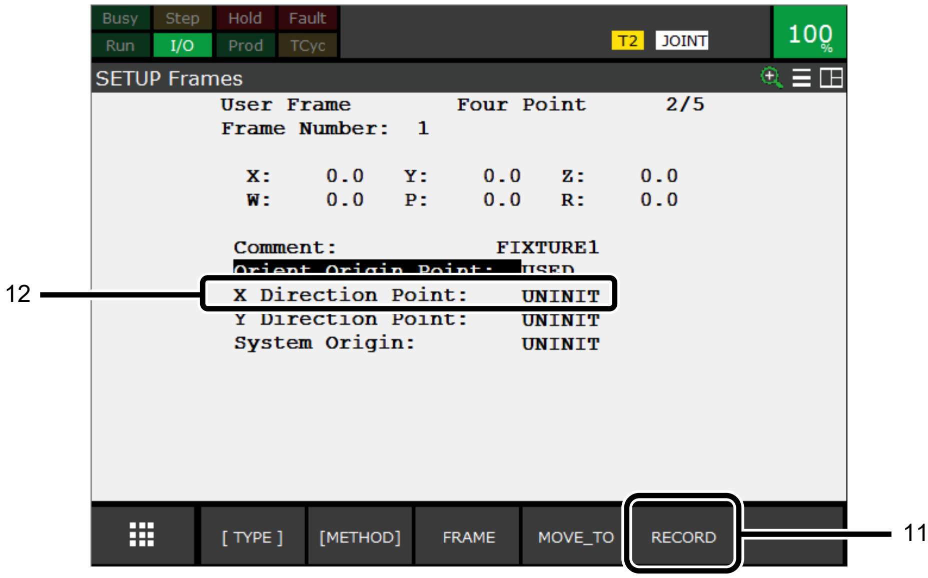


4 Place the cursor over the line of the user frame number to set.
5 Press F2 [DETAIL].
The setup screen for the user frame for the selected frame number will appear
6 Press F2 [METHOD].
7 Place the cursor over [Four Point] and press the [ENTER] key.
A screen for user frame setting using the four point teaching method will appear.



8 Enter a comment in the [Comment] field as required.
A comment to distinguish this frame from other user frames is recommended.
9 Place the cursor over [Orient Origin Point].
10 Jog the robot and touch up the X direction origin point with the pointer tool.

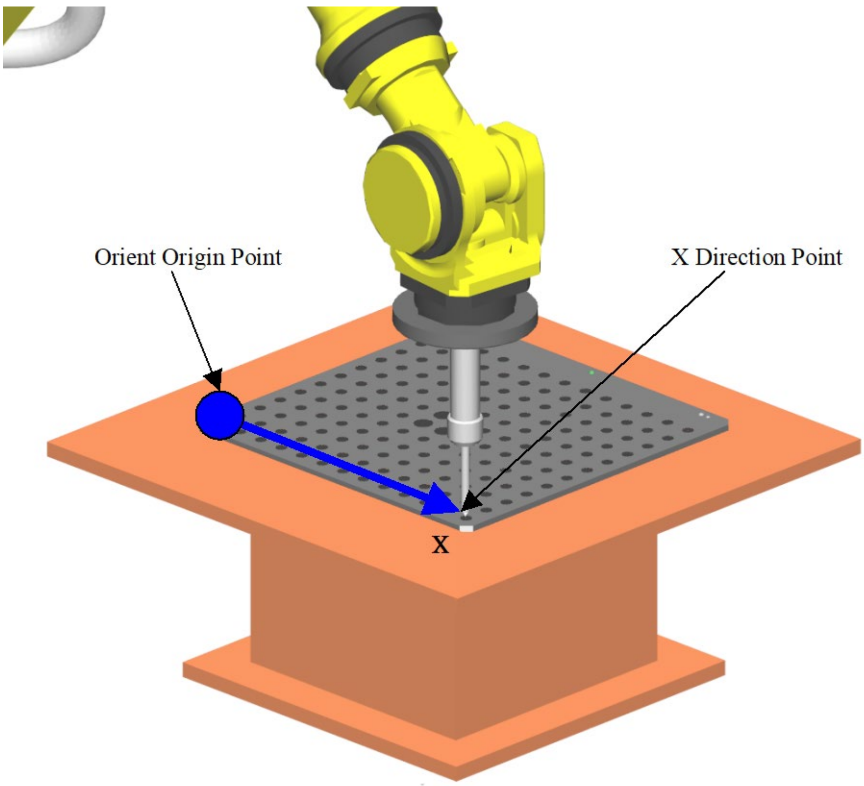


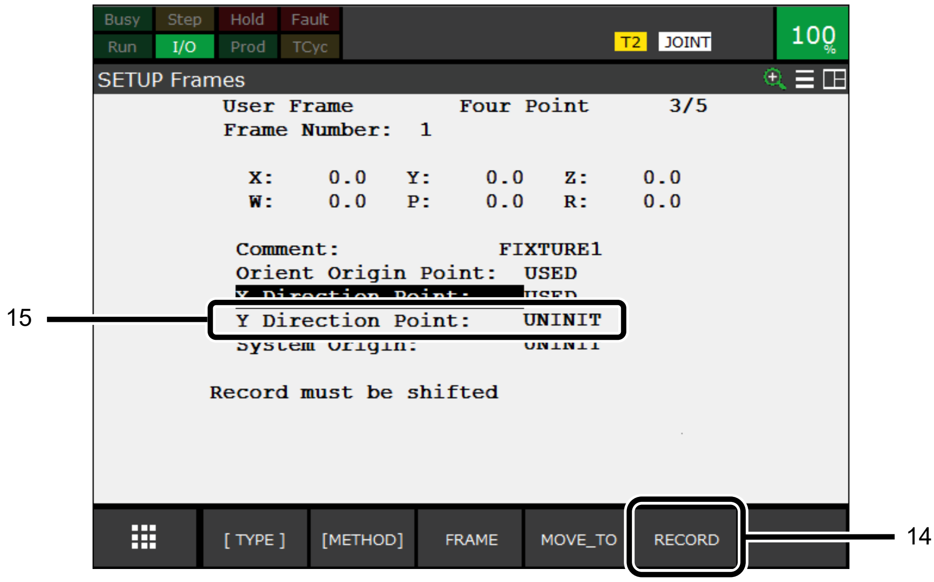


11 While holding down the [SHIFT] key, press F5 [RECORD].
The current position data will be entered as the X-axis origin point.
For the taught [Orient Origin Point], [Used] will appear.

12 Place the cursor over [X Direction Point].

13 Jog the robot and touch up the X direction point of the frame with the pointer tool.
A line drawn between the orient origin point and the touched up X direction point will be the X-axis of the frame.

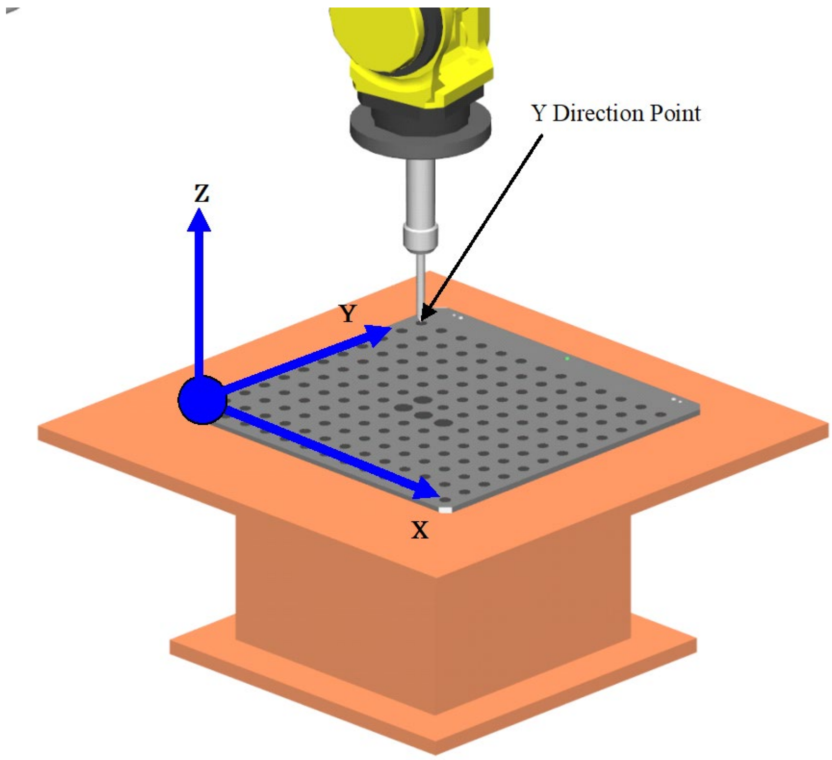


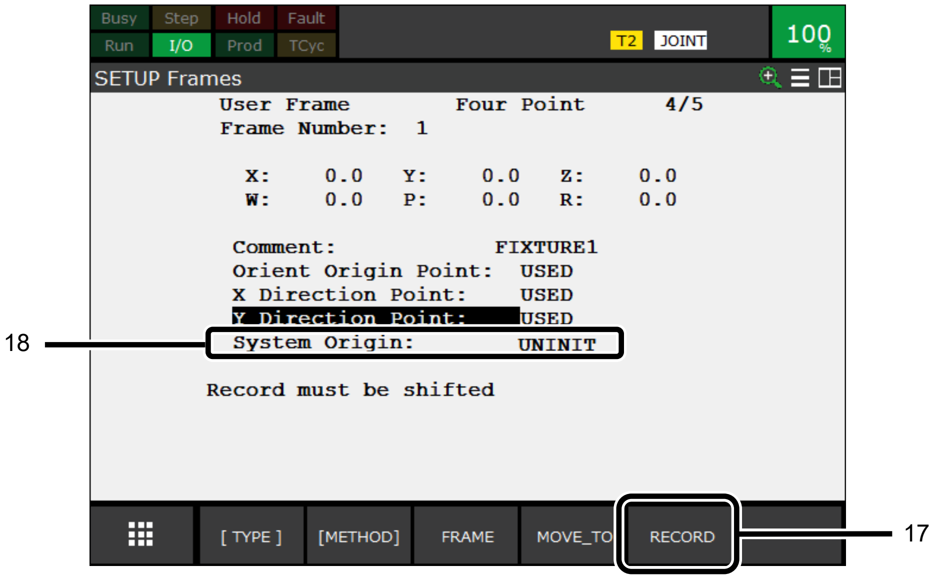


14 While holding down the [SHIFT] key, press F5 [RECORD].
The current position data will be entered as the X direction.
[USED] will be shown for the taught [X Direction Point].

15 Place the cursor over [Y Direction Point].

16 Jog the robot and touch up the Y direction point with the pointer tool.
Touching up the Y-axis direction will determine the X and Y plane of the frame.

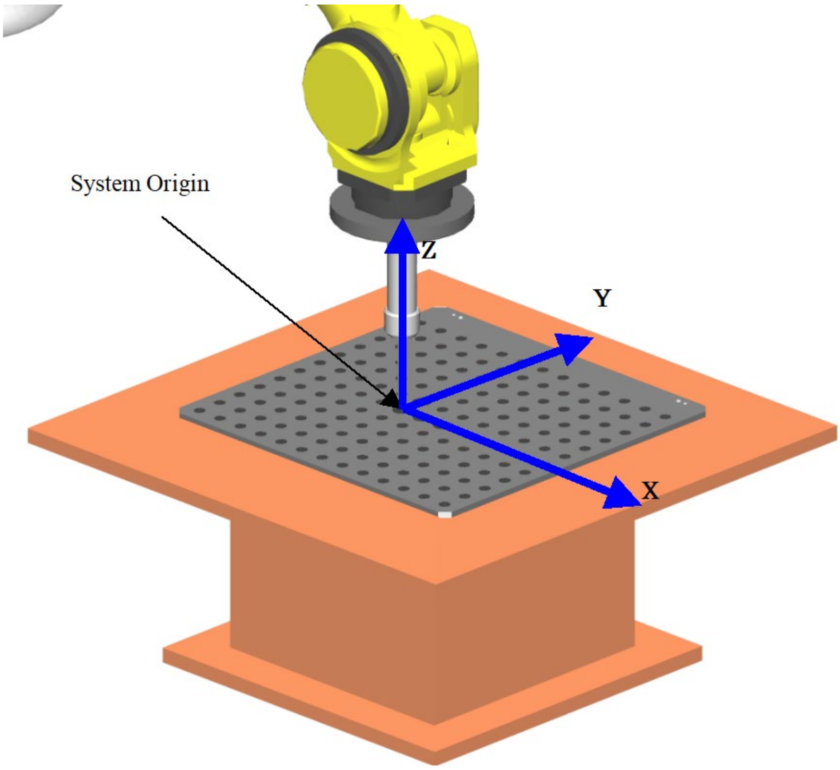


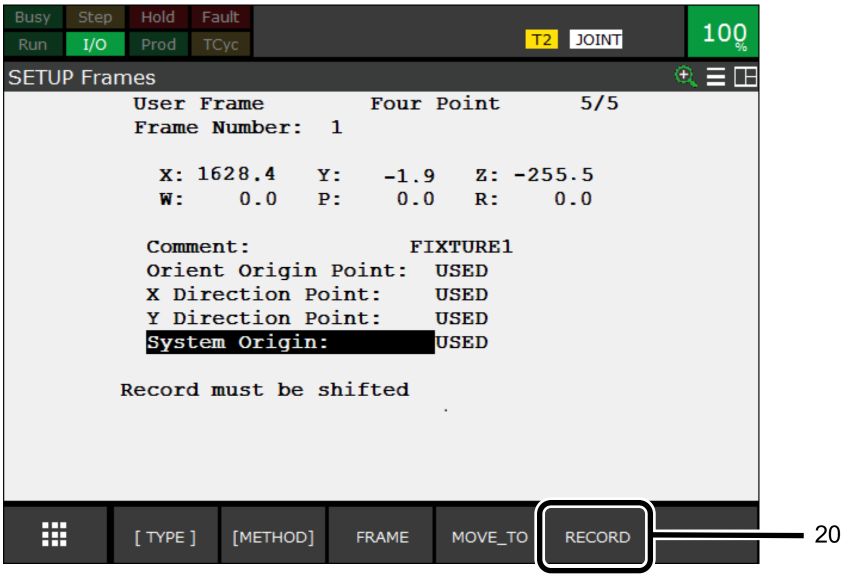


17 While holding down the [SHIFT] key, press F5 [RECORD].
The current position data will be entered as the Y-axis direction.
[USED] will be shown for the taught [Y Direction Point].

18 Place the cursor over [System Origin].

19 Jog the robot and touch up the orient origin point of the frame with the pointer tool.





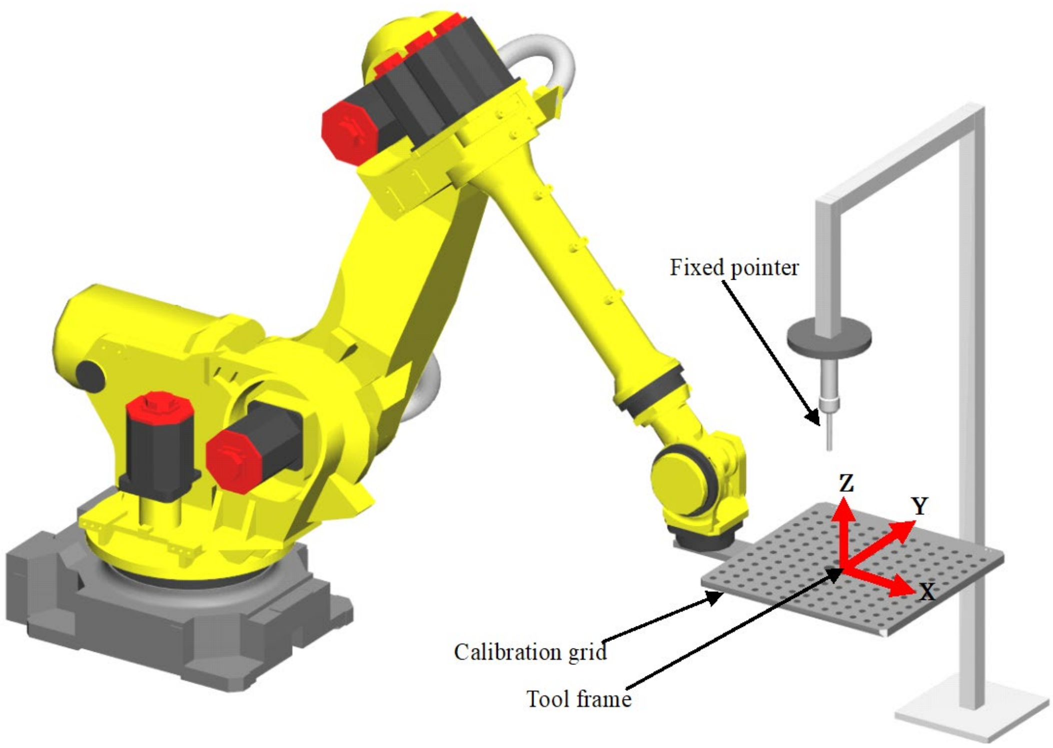
20 While holding down the [SHIFT] key, press F5 [RECORD].
The current position data will be recorded as the orient origin of the frame.
When all the touch-up points are taught, [Used] will be displayed. The user frame will be set.

21 Press the [PREV] key.
The User Frame list screen will appear.

22 Press F5 [RECORD] and enter the frame number.
The user frame that has been set will be set as the currently enabled user frame.

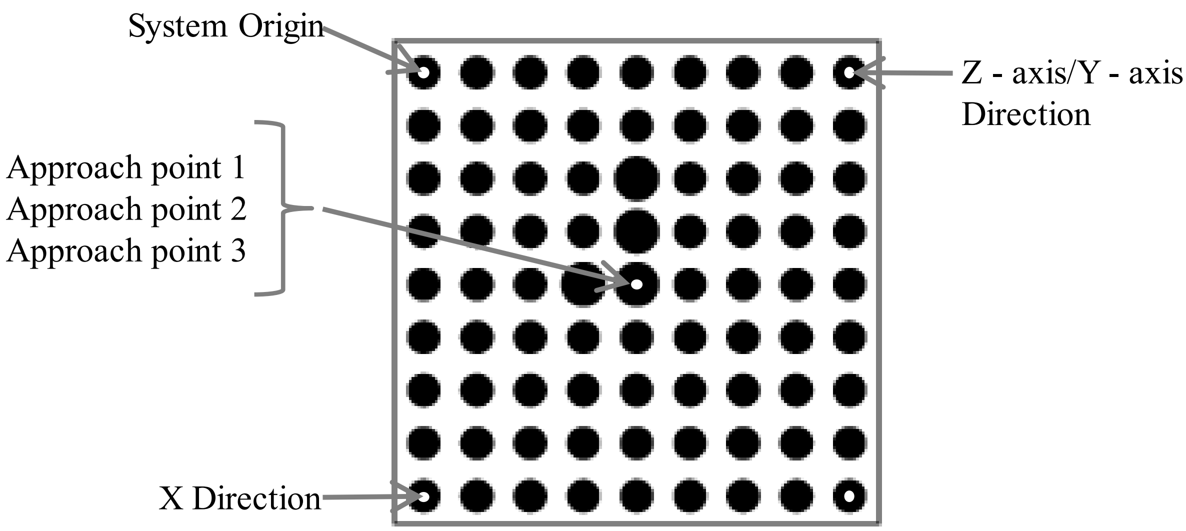
1.1.2 Tool Frame Setting

This subsection is explained a tool frame setting on the calibration grid that is mounted on the robot end of arm tooling.



Example of tool frame setting with a pointer tool

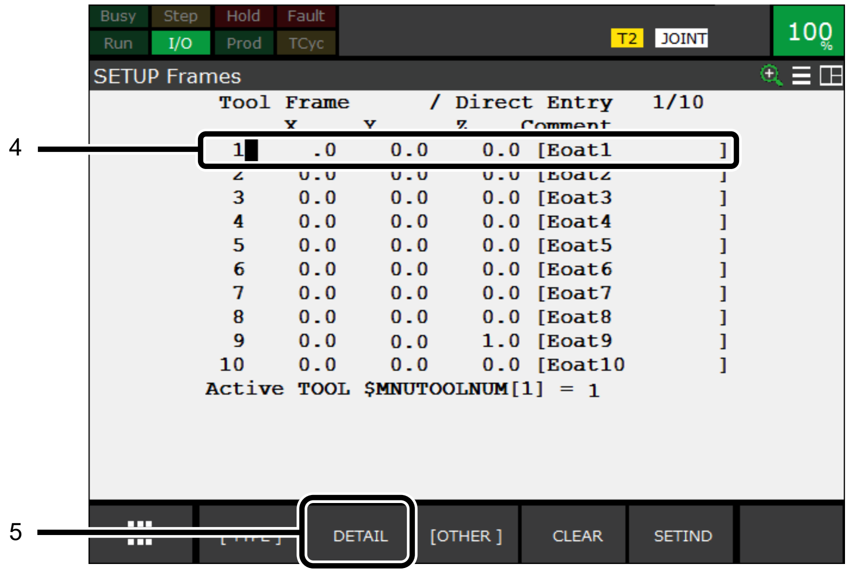
After the pointer for touch-up is secured to a secured stand, select “Tool Frame Setup / Six Point(XY)” or “Tool Frame Setup / Six Point(XZ)”, and teach the six points shown in the figure below by touch-up operation. The position of fixed pointer is arbitrarily.



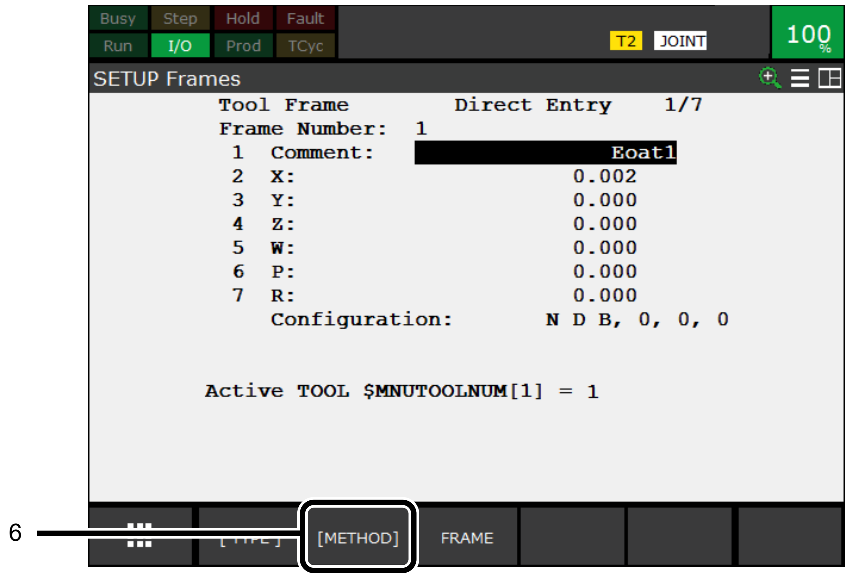
Six point teaching method touch-up points for a calibration grid

The user tool set using the “Tool Frame Setup / Six Point(XZ)” method is rotated by 90 degrees about the X-axis with respect to a desired coordinate system. Upon completion of setting the user tool frame by touch-up operation, manually enter the value of W plus 90.
In the example of this subsection, “Tool Frame Setup / Six Point(XY)” is explained. Make sure that the calibration grid is fixed securely to the robot end of arm tooling so that it remains in place while the robot moves. Positioning pins or other appropriate means may be used so that the calibration grid can be mounted at the same position for each measurement. Moreover, set the tool frame accurately on the calibration grid. If the accuracy of this frame setting is low, the precision in handling of a workpiece by the robot is also degraded.

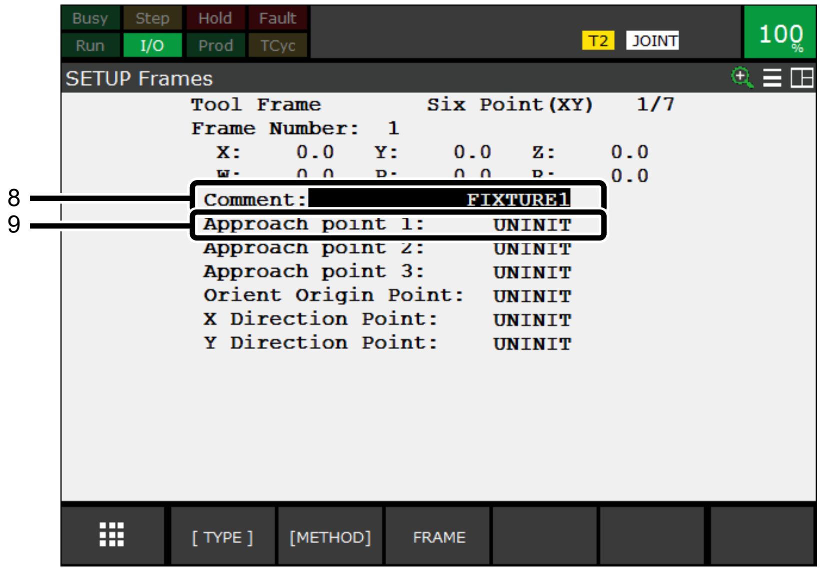
1 On the teach pendant, after selecting the [MENU] key → [Setup], place the cursor over [Frame] and press the [ENTER] key.
2 Press F3 [Frame].
3 Place the cursor over [Tool] and press the [ENTER] key.
The list screen for tool frames will appear.



4 Place the cursor over the line of the tool frame number to set.
5 Press F2 [DETAILS].
The setup screen for the tool frame for the selected frame number will appear.



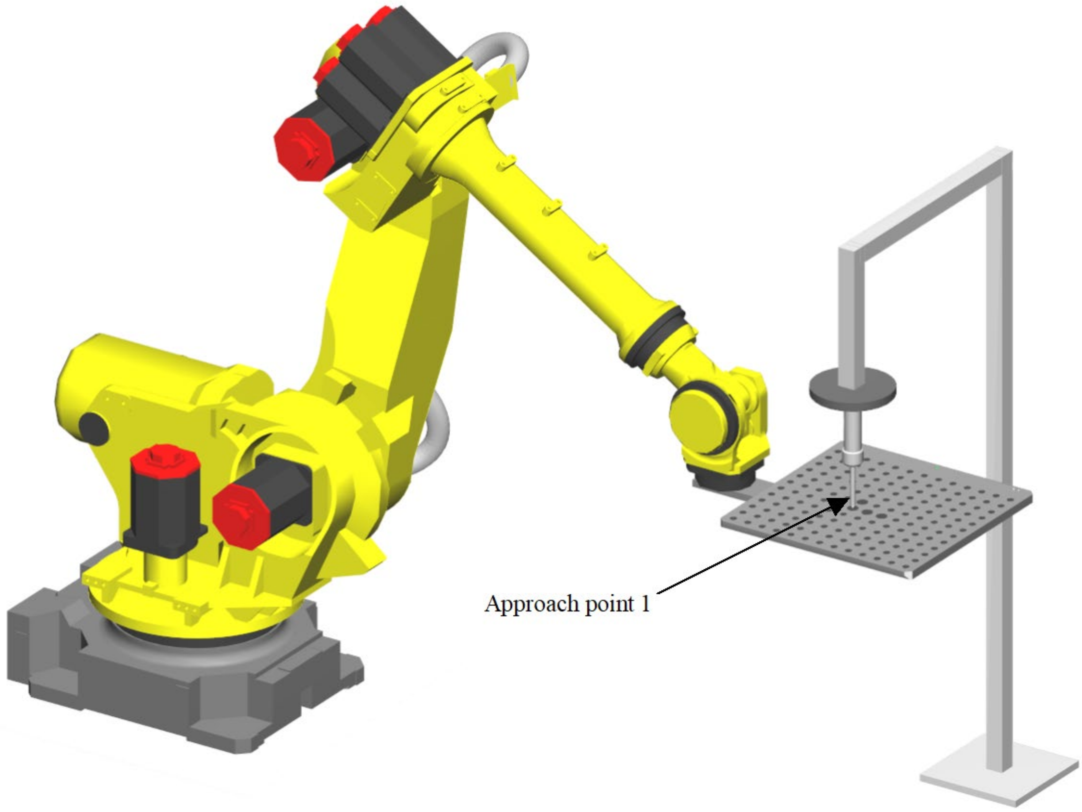
6 Press F2 [METHOD].
7 Place the cursor over [Six Point (XY)] and press the [ENTER] key.
A screen for tool frame setting using six points will appear.



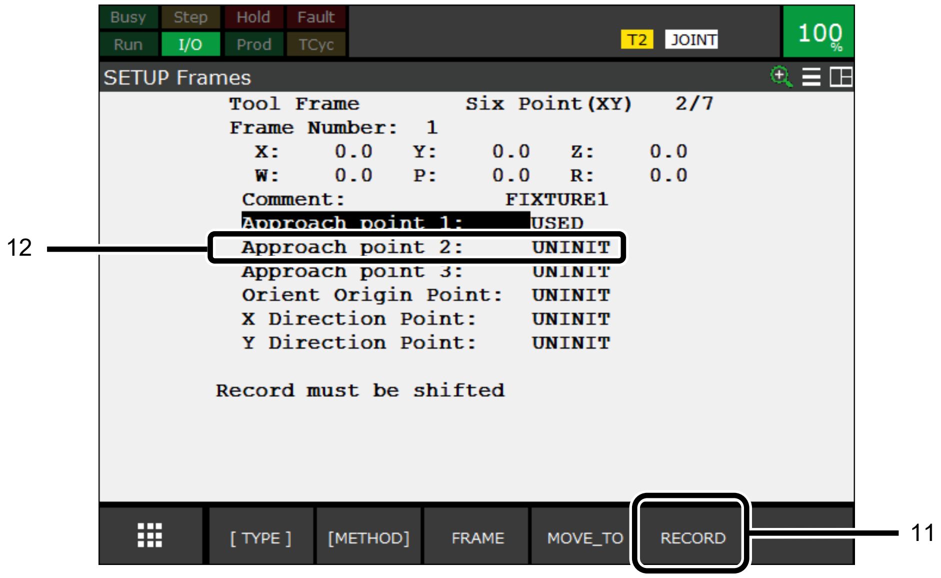
8 Enter a comment in the [Comment] field as required.
A comment to distinguish this frame from other frames is recommended..

9 Place the cursor over [Approach point 1].

10 Jog the robot and touch up the reference point 1 with the pointer tool.



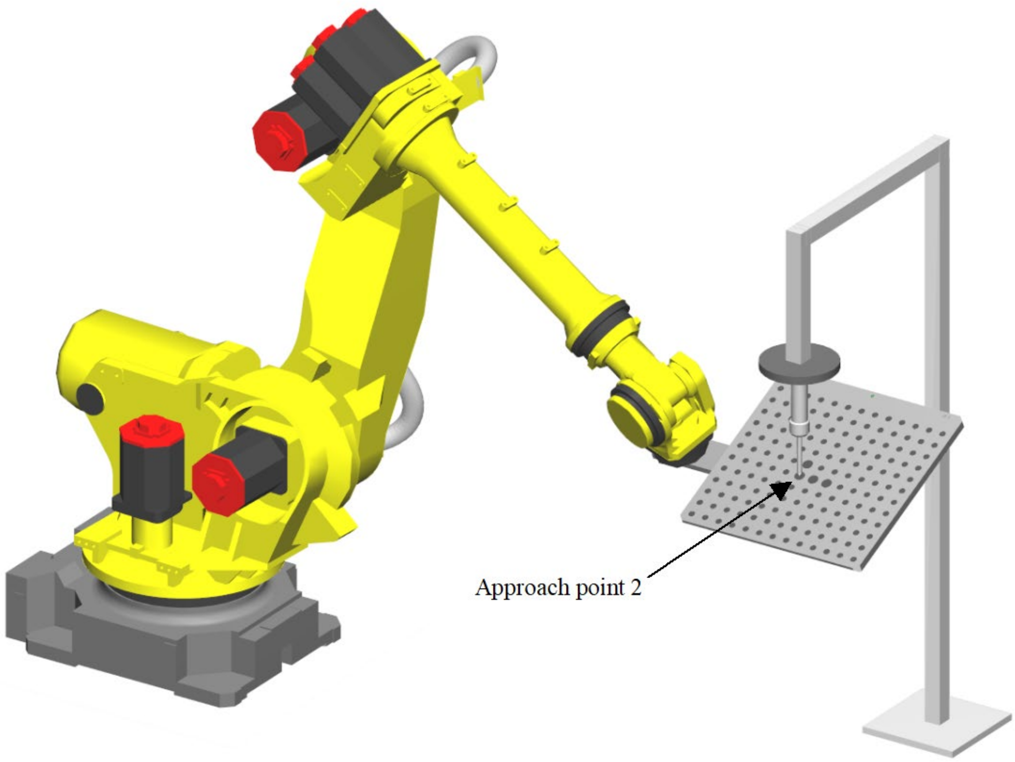
Touch-up of approach point 1



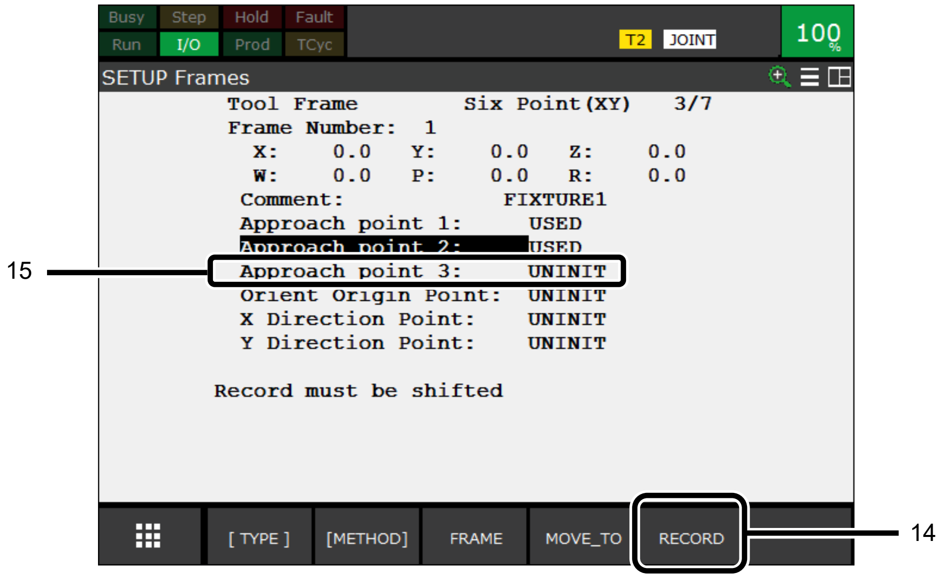
11 While holding down the [SHIFT] key, press F5 [RECORD].
The current value's data will be input as approach point 1.
For the taught [Approach point 1], [Used] will be displayed.

12 Place the cursor over [Approach point 2].

13 Jog the robot and touch up the reference point 2 with the pointer tool.
Touch up the same point as the reference point 1. However, change the robot attitude from that of the reference point 1.



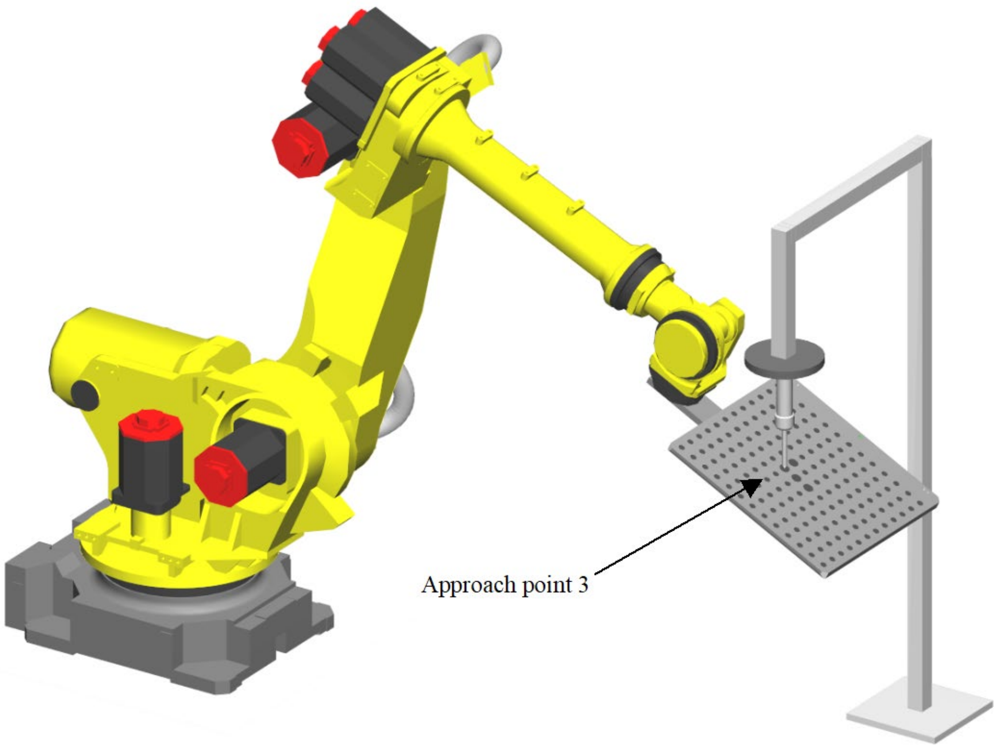
Touch-up of approach point 2



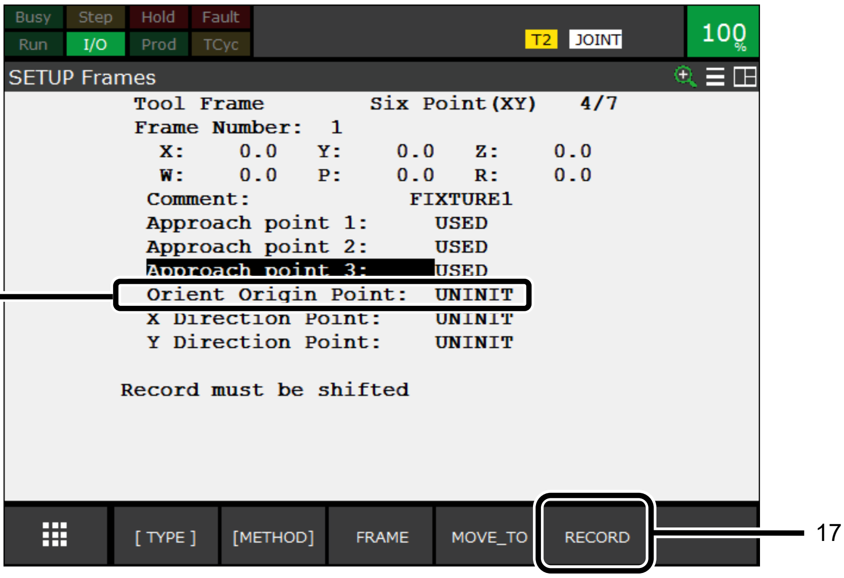
14 Press and hold the [SHIFT] key and press F5 [RECORD] to record the data of current position as the reference position. As for the [Approach point 2], [USED] is displayed.

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

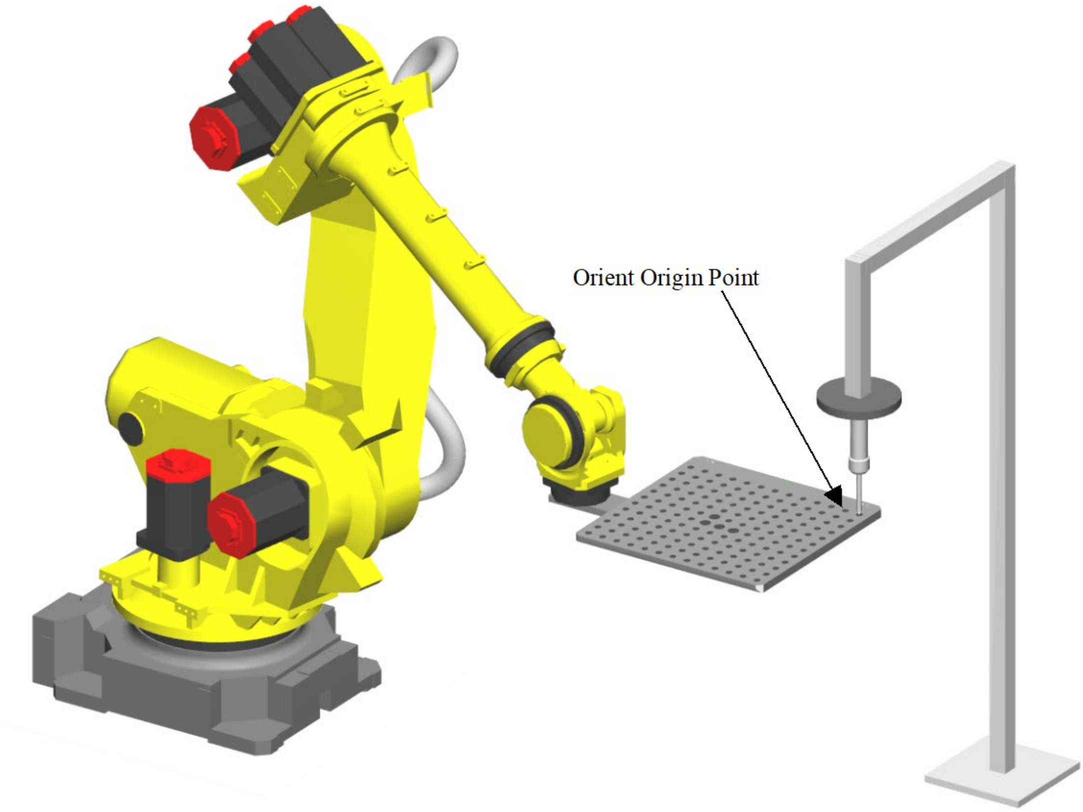
16 Jog the robot and touch up the [Approach point 2] with the fixed pointer. The position of [Approach point 2] is same position as the approach point 1. However, the posture of approach point 2 is different from the posture of approach point 1.



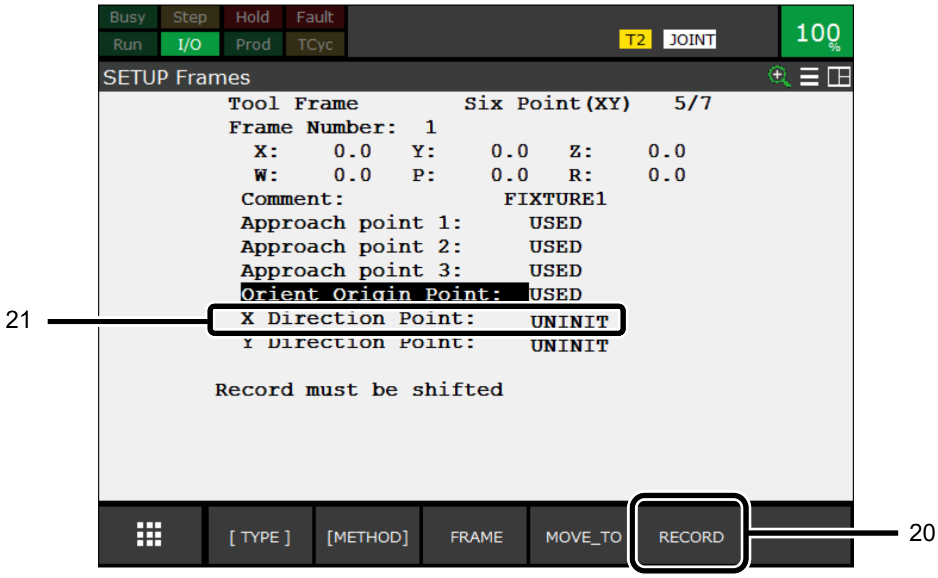
Touch-up of approach point 3



17 Press and hold the [SHIFT] key and press F5 [RECORD] to record the data of current position as the reference position. As for the taught reference point, [USED]is displayed.
18 Move the cursor to the [Orient Origin Point].
19 Jog the robot and touch up the Orient Origin Point with the fixed pointer.



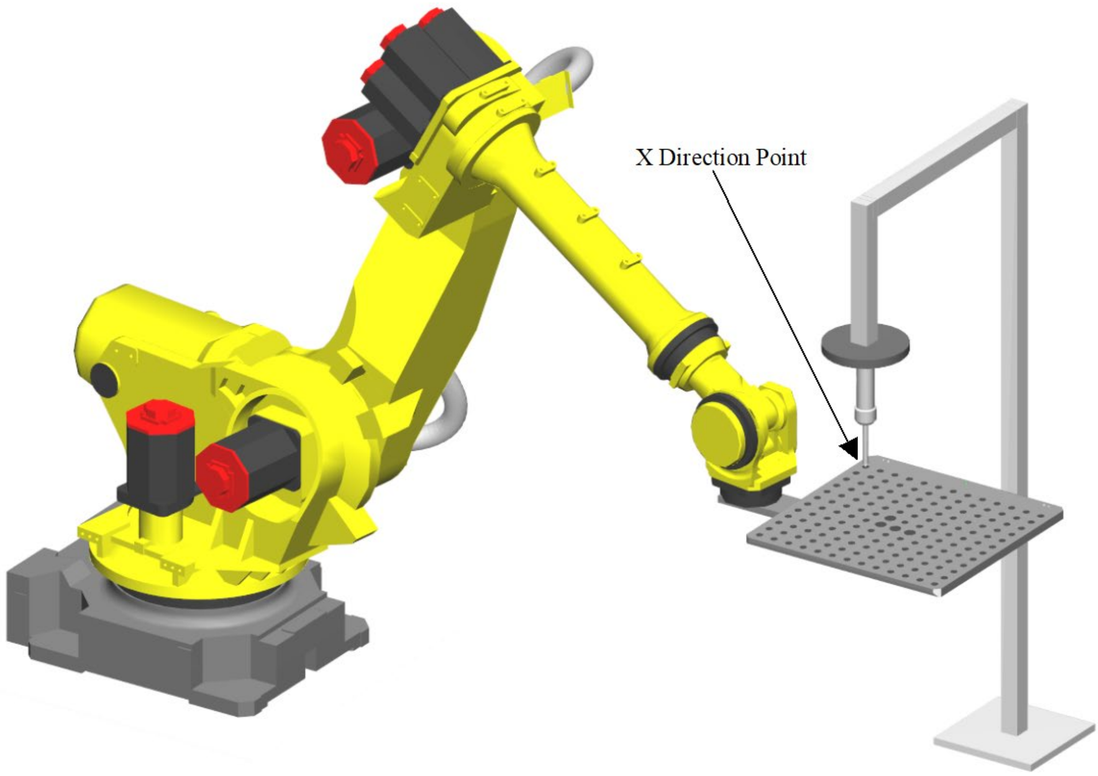
Touch-up of the point for the Orient Origin Point



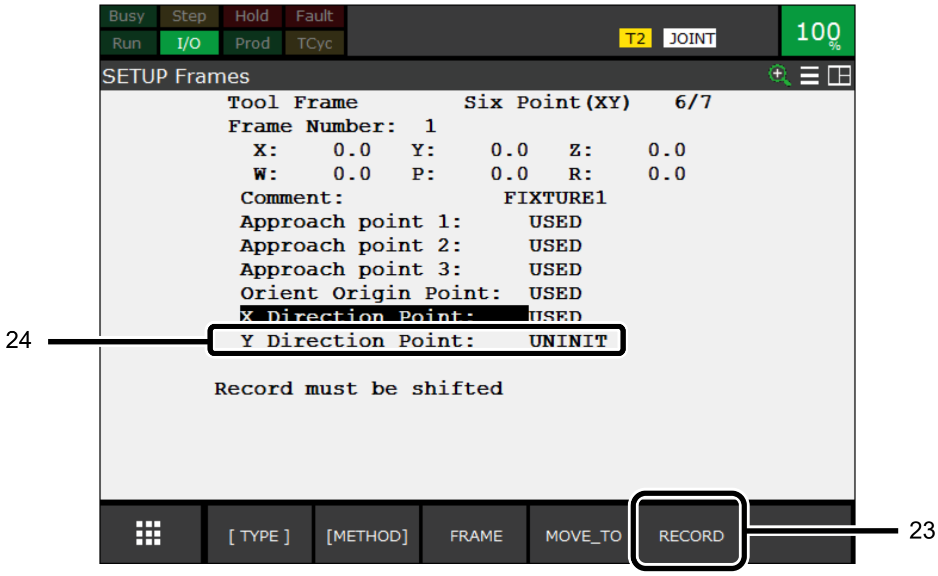
20 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the reference position. As for the taught reference point, RECORED is displayed.

21 Move the cursor to the X Direction Point.

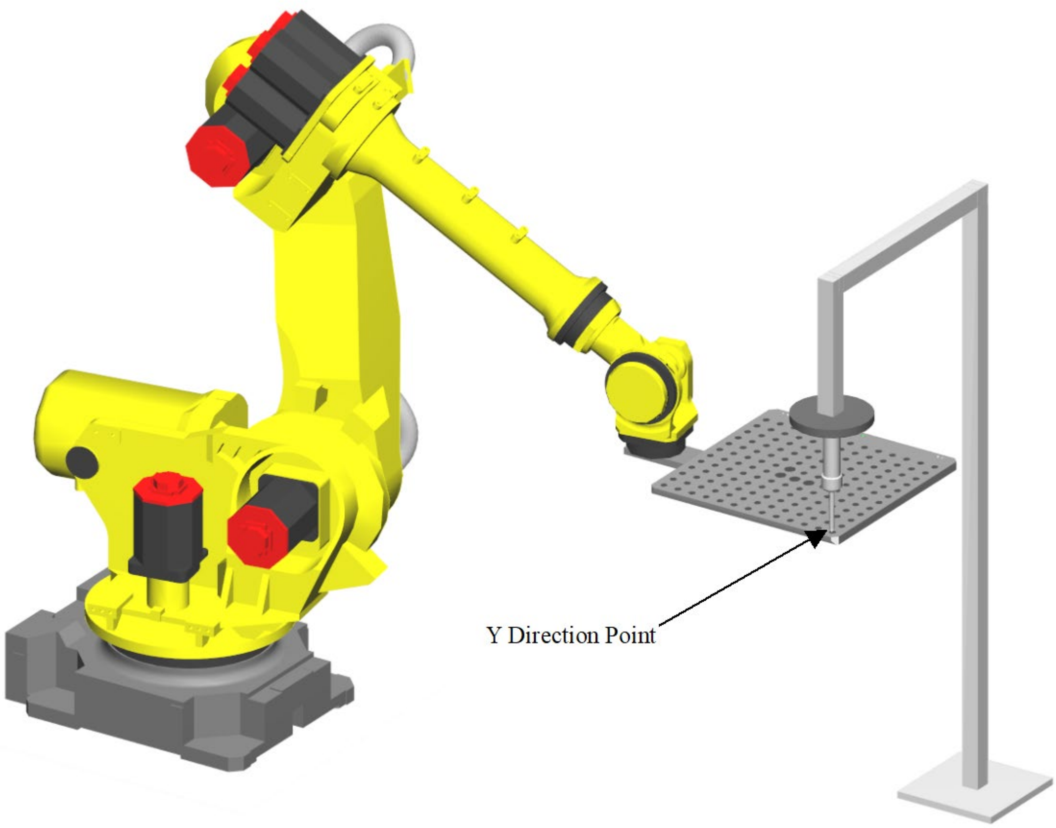
22 Jog the robot and touch up the X Direction Point with the fixed pointer.



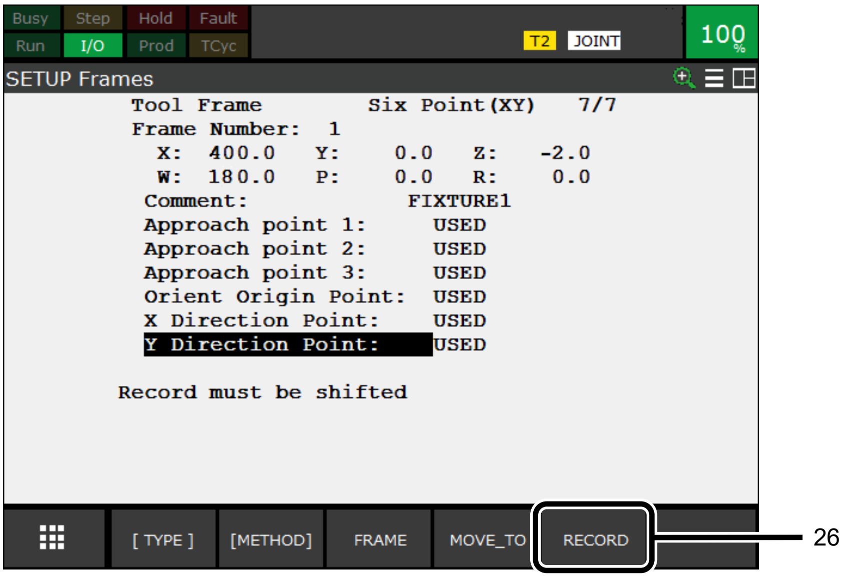
Touch-up of X direction point



23 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the reference position. As for the taught reference point, RECORED is displayed.
24 Move the cursor to the Y Direction Point.
25 Jog the robot and touch up the Y Direction Point with the fixed pointer.



Touch-up of Y direction point

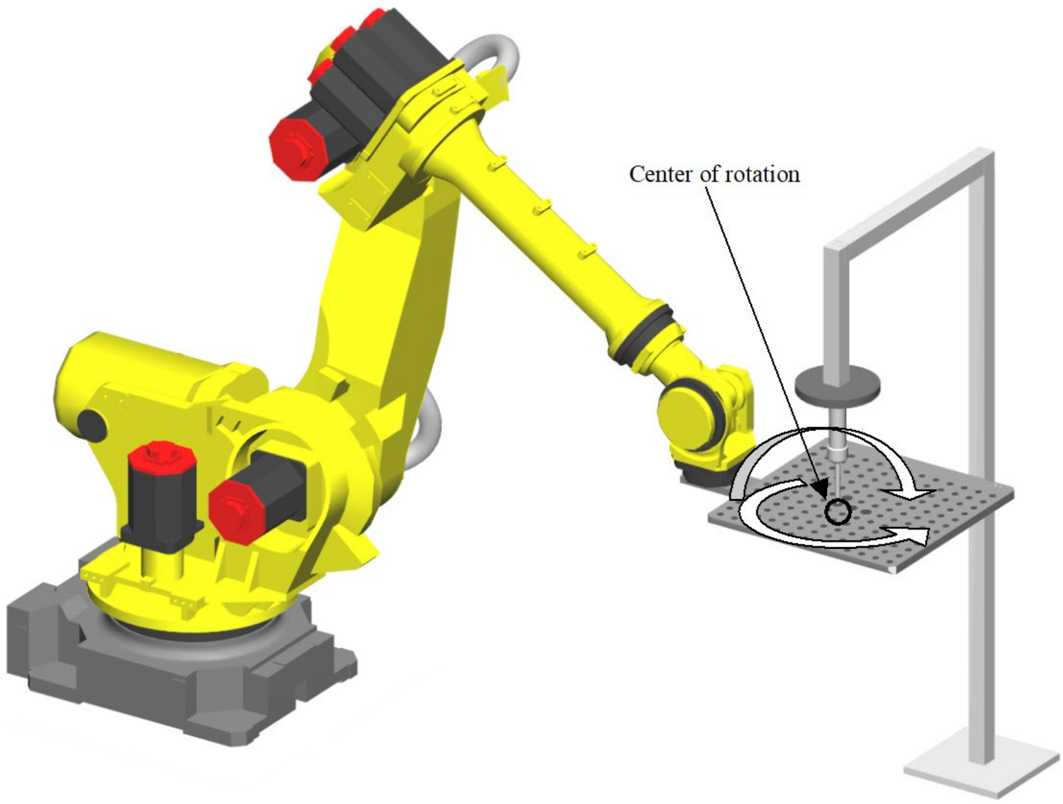


26 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the reference position. When all the reference points are taught, USED is displayed. The tool frame has been set.

27 To display the tool frame list screen, press the PREV key.

28 Check the TCP is set accuracy. Press F5 [SETIND] and enter the frame number.
The tool frame that has been set will be set as the currently enabled tool frame.

29 Jog the robot to move the origin point of the calibration grid close to the tip of the fixed pointer tool.



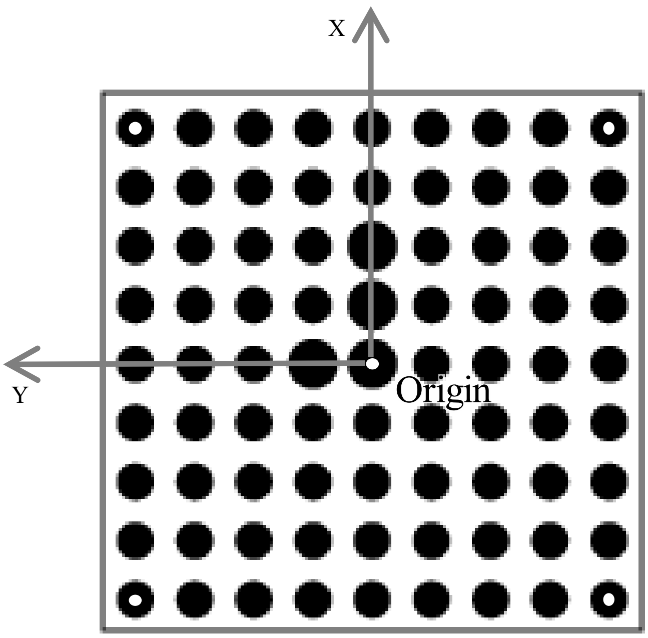
Check by moving the origin point of the calibration grid close to tip of fixed pointer tool

30 Operate the robot by jog operation around the tool frame, and change the orientation of the calibration grid (w, p, r). If the TCP is accurate, the tip of the pointer tool will always point toward the origin point of the calibration grid.

1.2 FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION

Function overview

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



Example of frame using calibration grid

Compared with the manual touch-up setting method, the function offers a number of merits, including accurate setting of the frame without requiring user skills, no need for touch-up pointers or to set the TCP for touch-up setting, and semi-automatic easy-to-do operation.

There are the following two methods to configure the grid frame setting.

- Open the camera data edit screen from the teach pendant and automatically measure the position of the calibration grid.
- Execute from the [*i*RVision utility] menu on the teach pendant.

If you want to calibrate the camera quickly, it is recommended that you should use the method to automatically measure the position of the calibration grid on the camera data edit screen.

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

> **Memo**
> A frame obtained from the grid frame setting on the camera data edit screen is not set as the user frame or tool frame. It is stored inside the corresponding camera data and used for the calibration of the camera data. This is useful for camera data calibration only, so if you want to set the user frame or tool frame on the grid pattern, configure the grid frame setting from the *i*RVision utility menu.

1.2.1 Setting Procedure from the Camera Data Edit Screen

Configure the grid frame setting on the camera data edit screen using the following procedure.

1 Set the calibration grid.

⇩

2 Edit the camera data.

⇩

3 Teach the measurement start position (camera data edit screen).

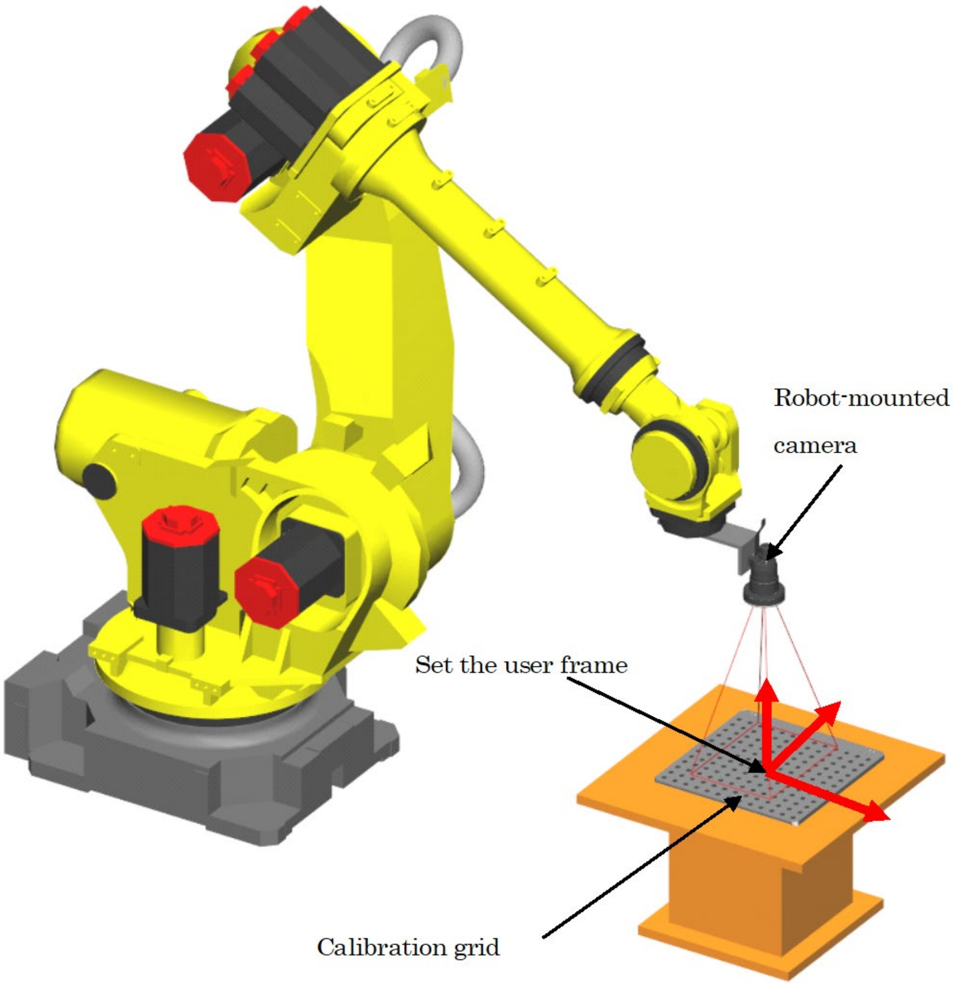
⇩

4 Run measurement (camera data edit screen).

1.2.1.1 Setting the calibration grid

When fixing the grid to a table

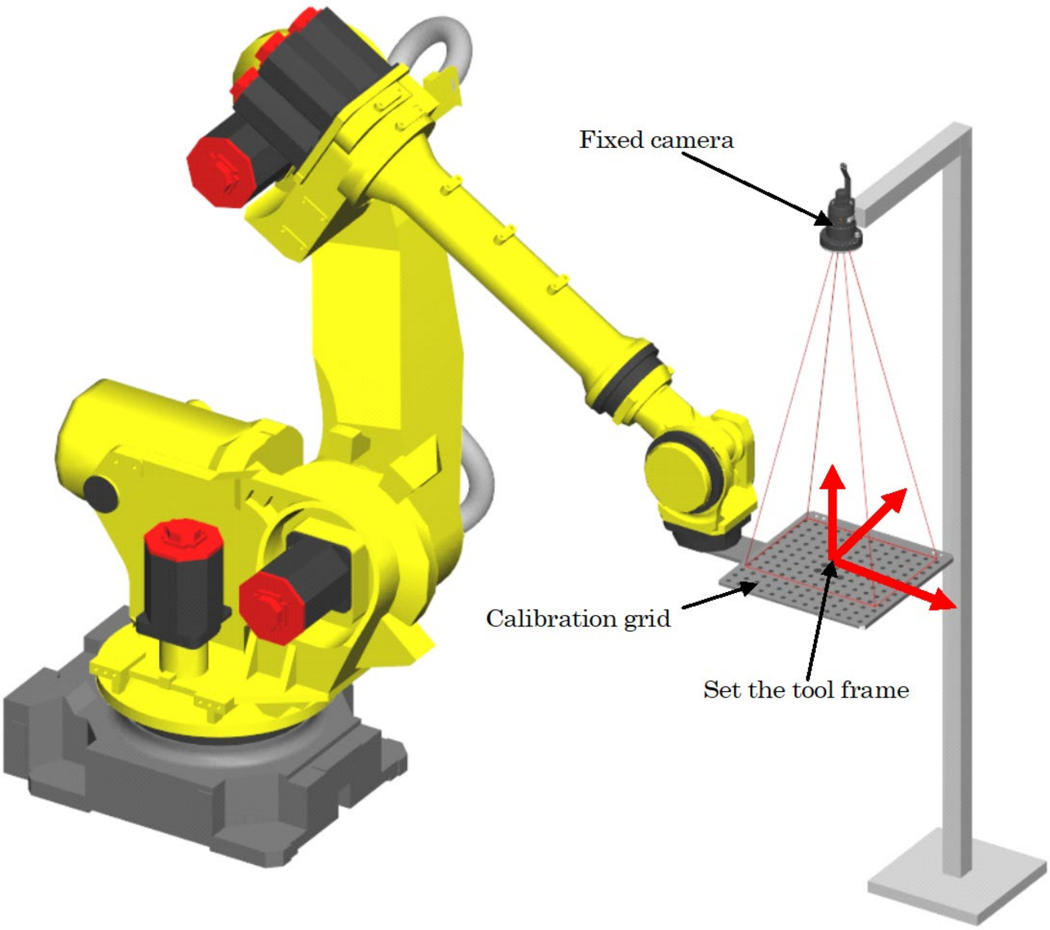
Measure the target using a camera attached to the robot end of arm tooling. You need to measure the calibration grid fixed to a table with the camera mounted on the robot end of arm tooling while moving the camera. Fix the position of the calibration grid viewed from the world frame of the robot. For a robot-mounted camera, that camera may measure the fixture position of the calibration grid. For a fixed camera, prepare a different camera that is attached to the temporary position on the robot end of arm tooling, and perform the grid frame setting function.



Example of using a fixed calibration grid

When attaching the grid to the robot end of arm tooling

Measure the calibration grid attached to the robot end of arm tooling in front of the fixed camera while moving the grid. Fix the position of the calibration grid viewed from the mechanical interface frame (wrist flange) of the robot. Your camera may be used for measurement. When there is not enough space for the robot to move around the field of view of your camera, prepare a different camera for measurement.



Example of using a calibration grid attached to the robot end of arm tooling

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

> **Memo**
> To prevent any excessive grid from being found mistakenly, it is recommended that you should make sure that the calibration grid is not dirty or scratched and place a plain sheet as a background.

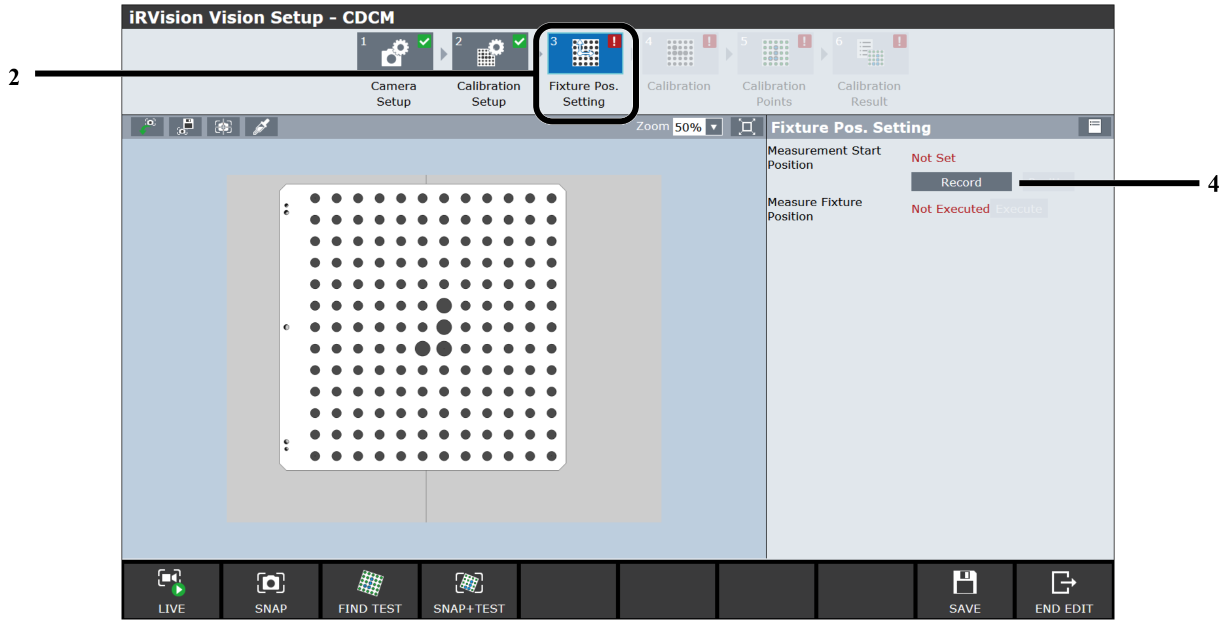
1.2.1.2 Editing the camera data

Open the camera data edit screen from the teach pendant and make settings to automatically measure the position of the calibration grid. Proceed with the setting up to the state where the ✅ icon is displayed in [1 Camera Setup] and [2 Calibration Setup] in the navigation area.

For details, refer to Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA" when using a fixed camera or Know-how Edition Section 2.2, "GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA" when using a robot-mounted camera.

1.2.1.3 Teaching the measurement start position

Teach the measurement start position as follows.

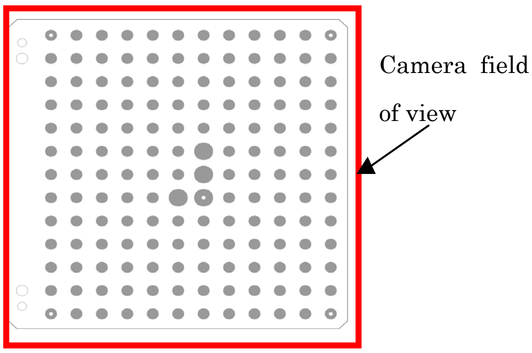


1 Press [3 Fixture Pos. Setting] in the navigation area.

2 Press [LIVE].
An image being captured by the camera is displayed in real time.

3 Jog the robot so that the optical axis of the camera is about perpendicular to the plate surface of the grid frame and all of the four large circles of the grid pattern are inside the field of view of the camera. A distance between the camera and the calibration grid must allow the camera to come into focus, usually about the same as the camera distance for calibration.

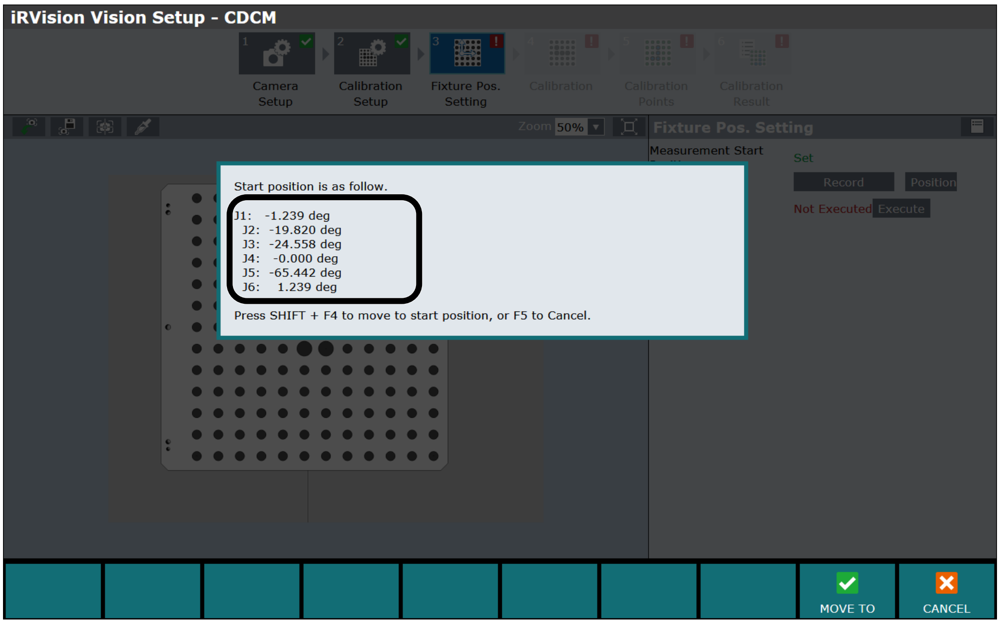
> **Memo**
> Grid Frame Setting measures the calibration grid with moving the robot on which the camera or the calibration grid is mounted. It is recommended that you should set a larger field of view for the calibration grid so that the four large circles of the grid pattern do not easily go outside the field of view.



Range of the camera field of view

4 Press [Record] in [Measurement Start Position].
The measurement start position is recorded, and [Measurement Start Position] changes to [Set].

5 To check the value of the trained measurement start position, press [Position] in [Measurement Start Position].
The value of each axis of the measurement start position is displayed, as shown below.



To return to the previous menu, press [CANCEL].

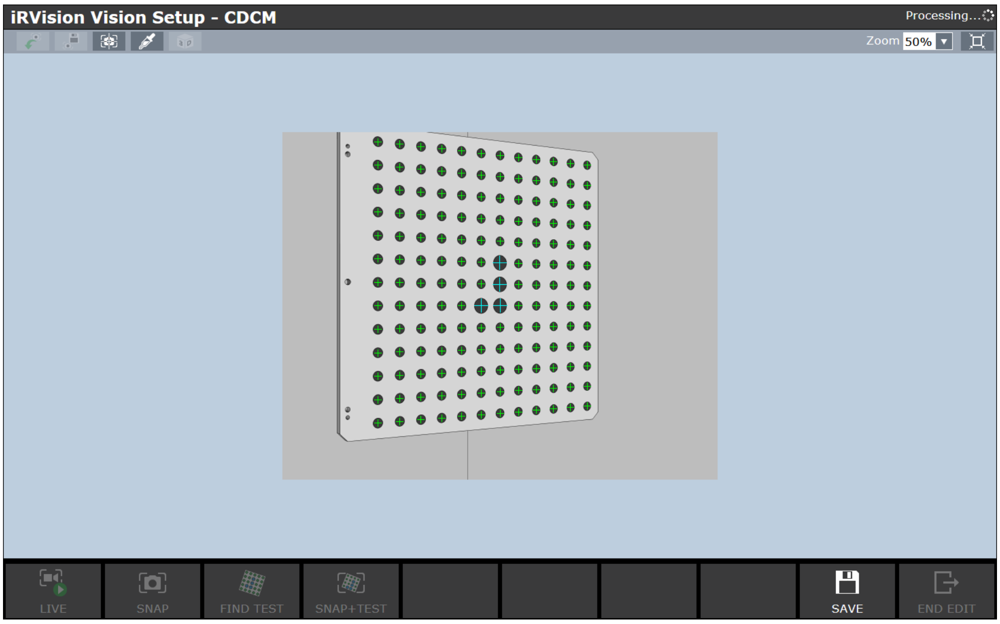
6 To move the robot to the trained measurement start position, press [OK] while holding down the [SHIFT] key on the teach pendant.

1.2.1.4 Running measurement

Perform measurement as follows, using the trained measurement start position as a reference.

1 Check that the robot is at the measurement start position.

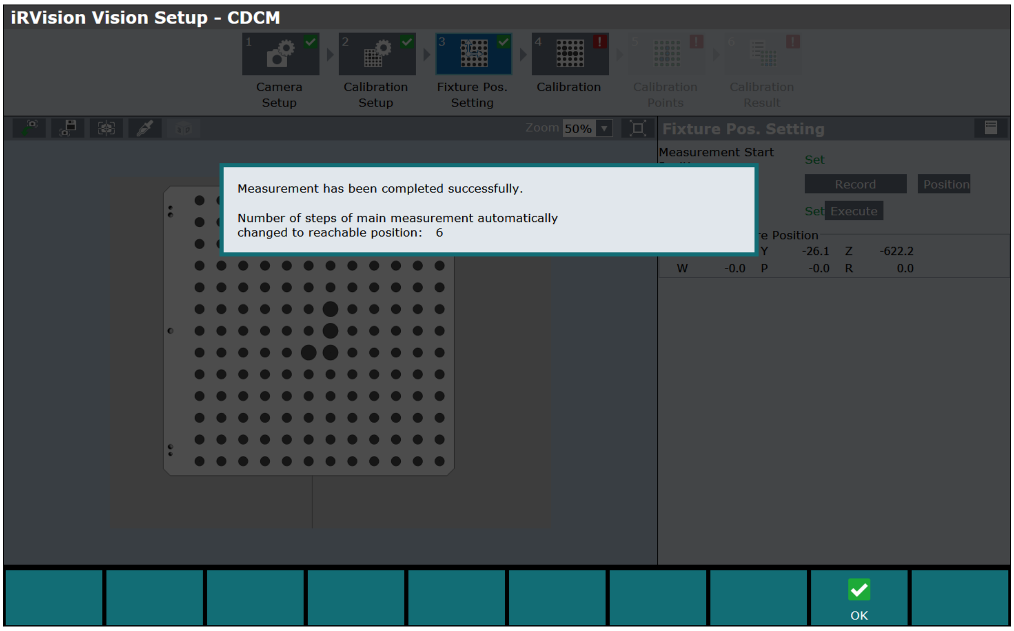
2 Press [Execute] in [Measure Fixture Position] while holding down the [SHIFT] key on the teach pendant.
It starts measurement, causing the robot to start moving. The screen changes while the robot is in operation, allowing you to check measurement images in real time.



⚠ CAUTION

1. Releasing [SHIFT] while measurement is in progress stops the measurement. In that case, perform the measurement again. You can resume it from where it stopped.
2. The robot usually performs operations within an expected range according to the parameter setting. However, the robot can make a motion beyond an expected range, depending on the parameter setting. When doing the measurement, check that the related parameters are set correctly and decrease the override to 30% or less to ensure that the robot does not interfere with peripheral equipment.
3. If another program is paused, the robot may not be able to move. In that case, abort the program using the [FUNC] menu on the teach pendant.

When the measurement is successfully completed, the following screen appears.
The robot stops with the camera facing the calibration grid straight and the origin of the calibration grid coming to the center of the image.



Checking the measurement

When the measurement is completed, the fixture position of the calibration grid is displayed on the screen. You can check if the displayed fixture position is correct using the following procedure.

1 Set the displayed position to a frame number that has not been set.
When the calibration grid is attached to the robot, set the position to the tool grid.
When the calibration grid is fixed, set the position to the user grid.

> **Memo**
> Set the displayed position on the frame screen from the teach pendant.

2 Switch to the frame set in the step 1.
3 Set the manual-feed coordinate system to the frame set in the step 1.
For the tool frame, press the [COORD] key to switch to [Tool].
For the user frame, press the [COORD] key to switch to [User].
4 Click the  icon in the image display area on the camera data edit screen.
5 Click [LIVE] on the camera data edit screen.
6 Jog the robot around WPR. It would be fine as long as the center position of the calibration grid does not deviate significantly from the center line of the image.

In the event of failure to measure

If the measurement fails, the screen returns to the camera data edit screen without displaying the measurement completion message.
Change the [1 Camera Setup], [2 Calibration Setup], and [3 Fixture Pos. Setting] setting items or the measurement start position, and then execute the measurement again. For details, refer to the description of setting the fixture position (Measure Automatically) in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

1.2.2 Setting Procedure from the *i*RVision Utility Menu

When you configure the grid frame setting from the iRVision utility menu, configure the grid frame setting on the iRVision utility menu using the following procedure.

1. Set the calibration grid.

⇩

2. Set the parameters (*i*RVision utility menu).

⇩

3. Teach the measurement start position (*i*RVision utility menu).

⇩

4. Run measurement (*i*RVision utility menu).

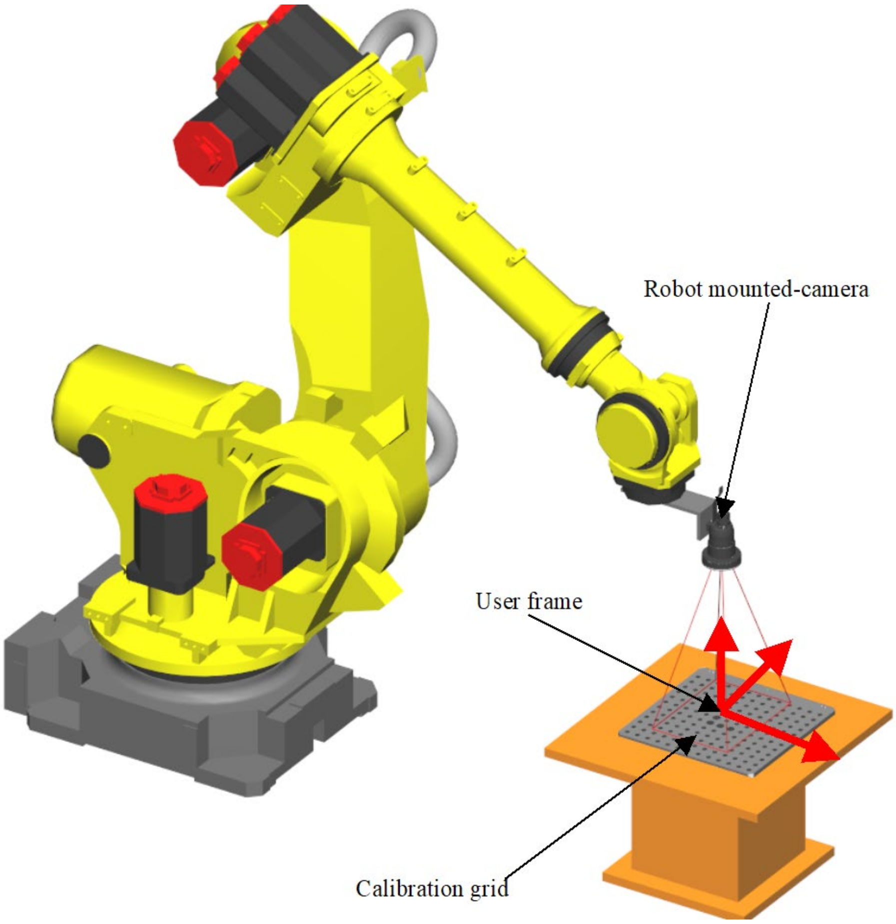
1.2.2.1 Mounting the calibration grid

When the calibration grid is secured to a fixed surface

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

Memo

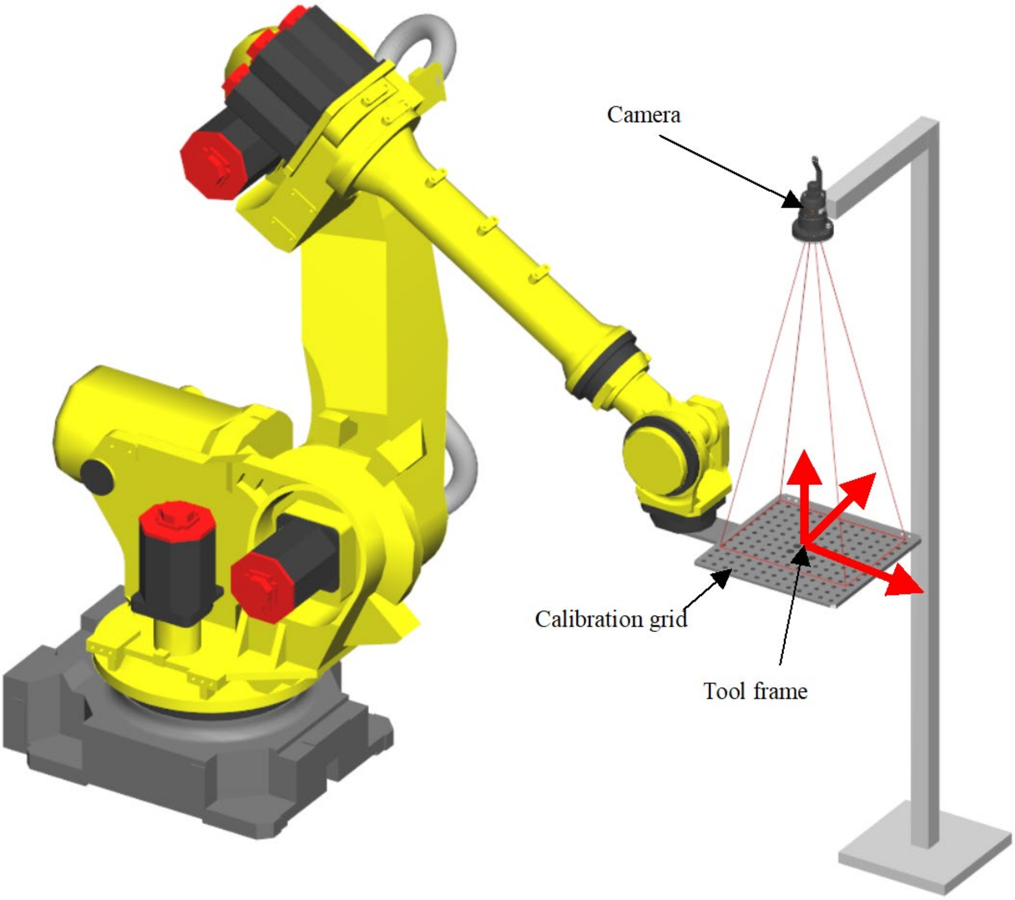
To set the position of the calibration grid for calibration, it is recommended that you should use the method to automatically measure the position of the calibration grid on the camera data edit screen.



Example of a fixed calibration grid

When the calibration grid is mounted on the robot

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



Example of a calibration grid attached to the robot hand

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

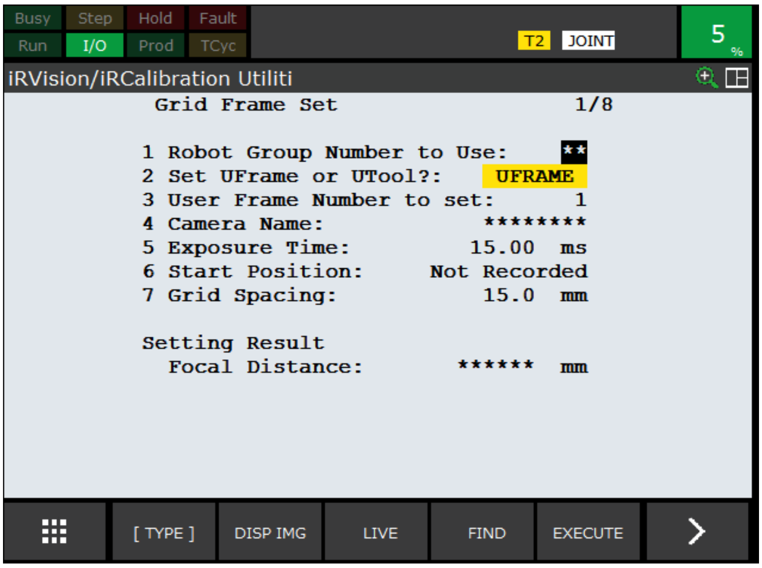
> **Memo**
> To prevent unnecessary circles from being found, check that the calibration grid is free of dirt and flaws. Spreading a plain sheet in the background is effective. Also, make sure to cover the printed text on the calibration grid.

1.2.2.2 Setting the parameters

Setup the parameters on [*i*RVision Utilities] screen of the teach pendant.

1 On the teach pendant, after selecting the [MENU] key → [*i*RVision], place the cursor over [Vision Utilities] and press the [ENTER] key.
The *i*RVision Utilities screen will appear.

2 Place the cursor over [Automatic Grid Frame Set] and press the [ENTER] key.
The [Grid Frame Set] screen will appear.



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

The following items will be displayed on the [Grid Frame Set] screen.

[Robot Group Number to Use]

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

[Set UFrame or UTool?]
Select the frame to be set with the Grid Frame Setting Function - user frame or user tool. When set the user tool with the calibration grid mounted on the robot, select F4 [UTOOL]. When set the user frame with the calibration grid installed on a table or other fixed surface, select F5 [UFRAME].

[User Frame Number to set]
Specify the number of the user frame to be set. This will only be displayed if [UFRAME] is selected in [Set UFrame or UTool?]. The range of specifiable user frame numbers is 1 to 9.

[Tool Frame Number to set]
Specify the number of the user tool to be set. The range of specifiable user tool numbers is 1 to 10. This will only be displayed if [UTOOL] is selected for [Set UFrame or UTool?].

[Camera Name]
Select a camera to use in the measurement. Place the cursor over the line of [Camera Name], then press F4 [FIND], and a list of cameras will be displayed. By selecting from the list, specify the camera to use for the measurement.

[Exposure Time]
Specify the exposure time for the camera to capture an image (Shutter speed). The larger the value, the brighter the images that will be snapped.
Adjust the exposure time so that the black circles of the calibration grid are clearly visible.

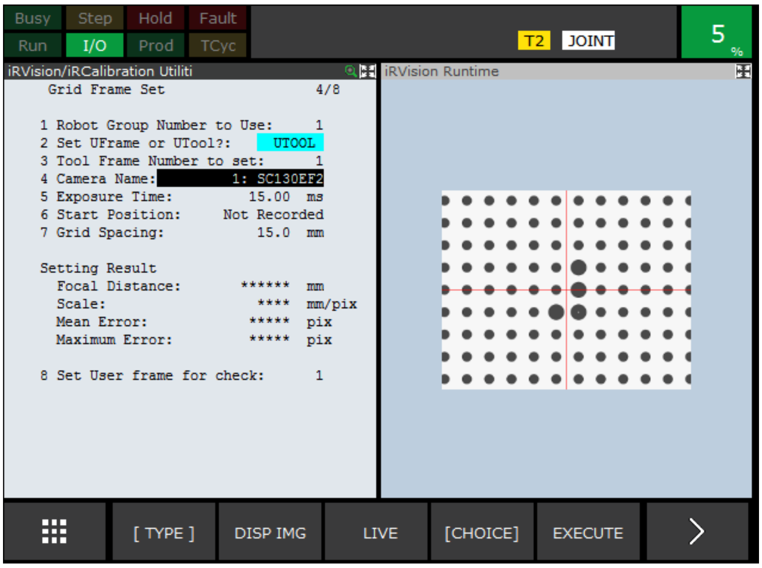
[Start Position]
Teach the position where measurement is to be started. If the position has been taught already, [Recorded] will be displayed, and if it hasn't been, [Not Recorded] will be displayed.
In the case of [Not Recorded], measurement cannot be executed. Be sure you always teach the start position before measurement.
For the procedure to teach the start position, refer to Know-how Edition Subsection 1.2.1.3, "Teaching Start Position".

[Grid Spacing]
Set the grid spacing of the calibration grid in use.

[Check Result]
This item is displayed when measurement is completed. For details, refer to the description of checking the measurement result in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

[Check Tool/User Frame Setup]
This item is configurable after measurement. If measurement is not completed, this item cannot be set. For details, refer to the description of checking the measurement result in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

F2 [DISP IMG]
The Automatic Grid Frame Set screen and Vision Runtime screen will be displayed as follows.



F3 [LIVE]

A live image for the selected camera will be displayed on the Vision Runtime screen. When a live image is displayed, it changes to F3 [STOPLIVE] and if F3 [STOPLIVE] is pressed, live image display will be stopped.

F4 [FIND]

Detect a grid pattern. The detection result will be displayed on the Vision Runtime screen.

F7 [DEFAULT]

The set values will be changed to the initial values. [Camera Name] and [Start Position] will be returned to their initial values so that you can set them again.

F8 [LED TYPE]

The screen to set the LED light integrated into the camera package is displayed. For details on the LED light setting, refer to the description of setting the LED light in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

F9 [MOVE_LIM]

The robot moves during the measurement of the grid frame, and the screen to set the move amount limit for this measurement is displayed. For details on the move amount limit setting, refer to the description of setting the move amount limit in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

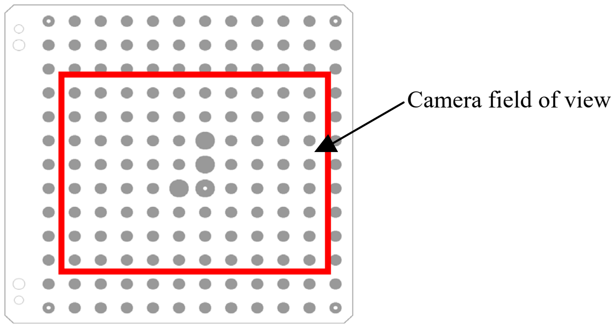
1.2.2.3 Teaching start position

Teach the start position using the following procedure.

1 If Vision Runtime is not displayed, press F2 [DISP IMG].
2 Place the cursor over [Start Position].
3 Jog the robot so that the camera's optical axis is approximately perpendicular to the plate surface of the calibration grid and that all of the four large black circles of the calibration grid are inside the camera's field of view. The distance between the calibration grid and the camera should be appropriate for the grid to come into focus, which is, under normal circumstances, roughly the same as the distance at which camera calibration is performed.

Memo

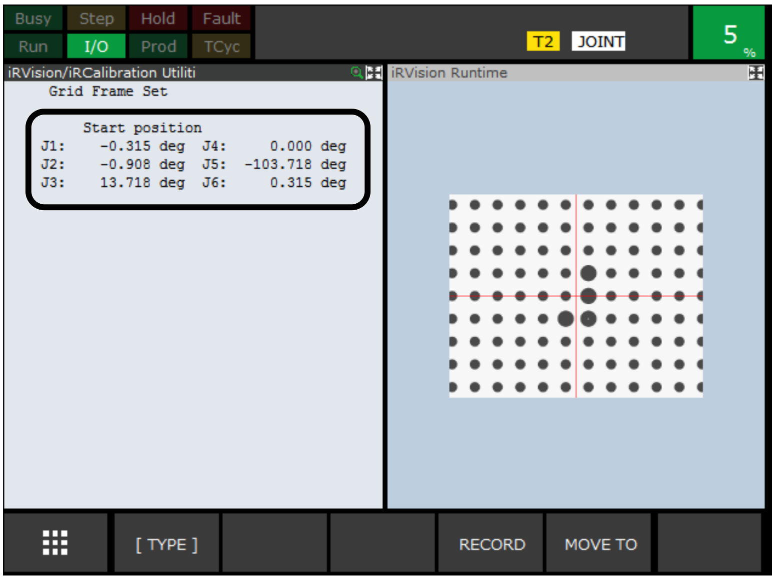
For Automatic Grid Frame Set, measurement is performed by panning and rotating the camera attached to the robot's gripper or the calibration grid. It is recommended that you set the field of view to something quite large in relation to the calibration grid, so that the four large black dots will not be outside of the field of view.



Camera field of view

4 While holding down the [SHIFT] key, press F4 [RECORD].
The start position will be recorded, and [Start Position] changes to [Recorded].

5 To check the trained start position, press F3 POSITION. The value of each axis of the start position is displayed, as shown below.



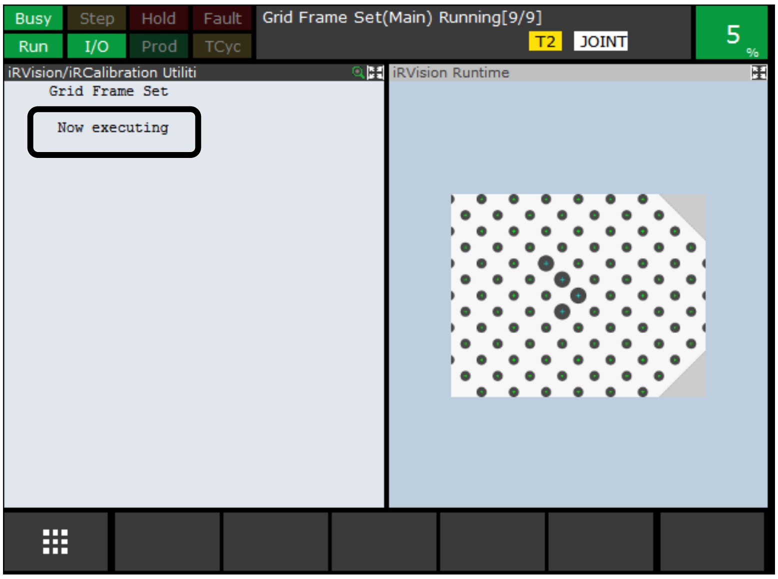
To return to the previous menu, press PREV.

6 When moving the robot to the taught start position, press F5 [MOVE TO] while pressing the [SHIFT] key.

1.2.2.4 Run measurement

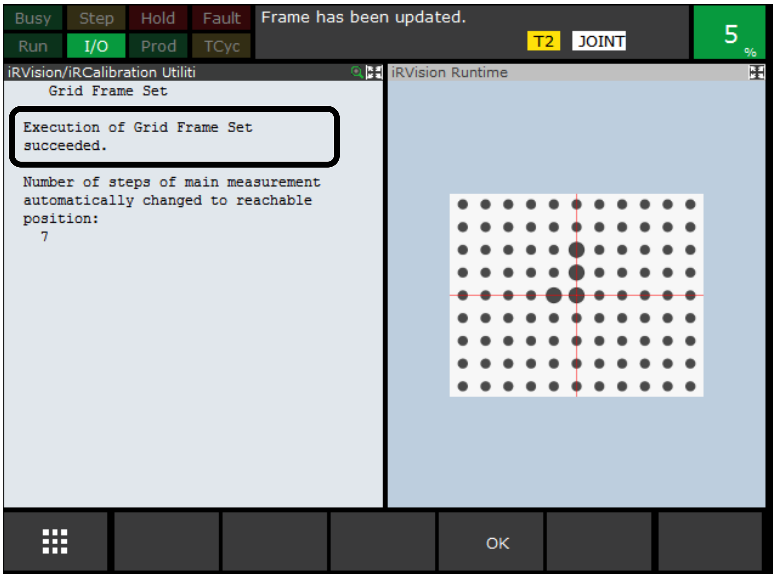
Perform measurement as follows, using the taught start position as a reference.

1. If Vision Runtime is not displayed, press F2 [DISP IMG].
2. Check the parameter setup on the [Automatic Grid Frame Set] screen.
3. Check that the robot is at the start position.
4. While holding down the [SHIFT] key, press F5 [EXECUTE].
   The robot will start the operation, and measurement will be executed. A message saying 'Now executing' will appear during the operation.



> ⚠ **CAUTION**
> 1 The measurement will stop if you release the [SHIFT] key during measurement. In such cases, redo the measurement. The measurement can be resumed from where it was stopped.
> 2 The measurement will stop if you perform an operation that moves to another screen during measurement, such as pressing the [SELECT] key on the teach pendant. In such cases, open the [Automatic Grid Frame Set] screen and redo the measurement. The measurement can be resumed from where it was stopped.
> 3 Although the robot will perform the decided motion to some extent, depending on the settings, it is possible that it will move with an unexpected motion range. When executing measurement, check that the setup of parameters is correct, and be careful to lower the override so that the robot will not interfere with devices.
> 4 The robot may not be able to operate if other programs are in a paused state. In such cases, press the [FCTN] key and end the programs.

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



5 If you press F4 [OK] is pressed, you will return to the Automatic Grid Frame Set screen.

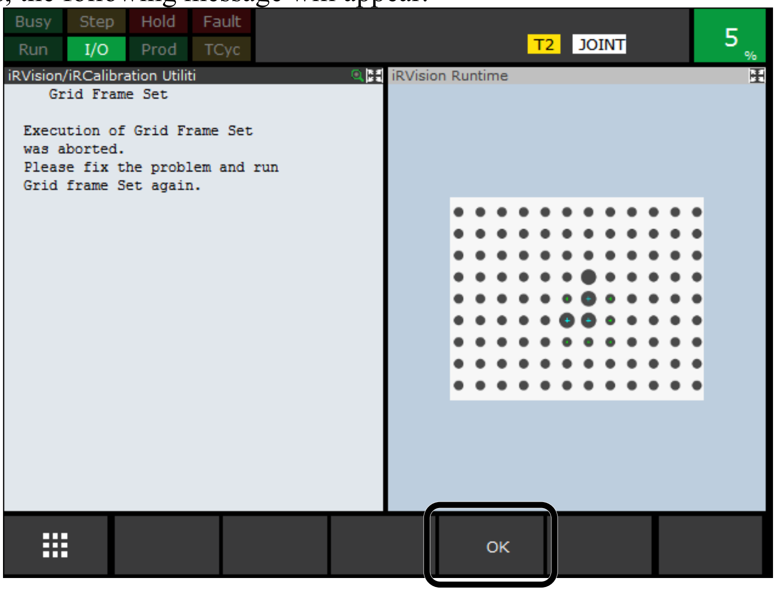
Measurement check

The grid frame will be set depending on the measurement. The set frame can be checked using the following procedure.

1 Set the manual feed frame as the frame for automatic grid frame set.
For a tool frame, press the [COORD] key and switch to [Tool].
For a user frame, press the [COORD] key to switch to [User], and specify the tool frame number that was specified in [Camera User Tool] in [Tool] under the jog menu, using the number keys.
2 Press F3 [LIVE] to start the display of a live image, and move the robot by jog operation around the WPR of the selected tool frame. There will be no problem unless the center position of the grid pattern is significantly far from the center line of the image.

In the event of failure to measure

If measurement fails, the following message will appear.



If F4 [OK] is pressed, the screen will return to the original screen.
After changing the setup parameters, measurement can be redone by pressing F5 [EXECUTE] while holding down the [SHIFT] key.

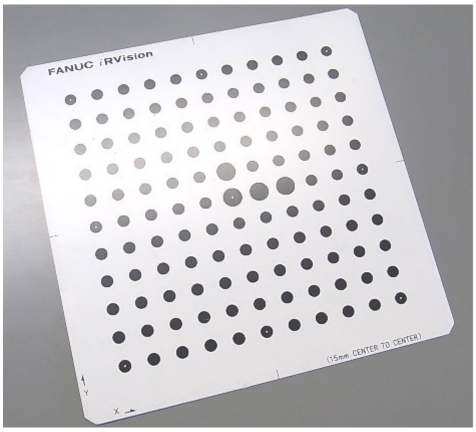
2 CAMERA DATA SETTING

This chapter explains the settings for camera data.
Create camera data and perform camera setup and calibration. Camera calibration is the work of setting where the camera is installed as seen from the robot. Complete calibration before teaching a vision process. There are three methods to calibrate a camera. This chapter explains them using the following structure.

- Know-how Edition Section 2.1, "GRID PATTERN CALIBRATION WITH A FIXED CAMERA".
- Know-how Edition Section 2.2, "GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA".
- Know-how Edition Section 2.3, "ROBOT-GENERATED GRID CALIBRATION".

2.1 GRID PATTERN CALIBRATION WITH A FIXED CAMERA

Grid pattern calibration is a general-purpose calibration method for cameras that uses a special jig called a calibration grid. When using grid pattern calibration, prepare a calibration grid in advance. Usually, prepare a calibration grid which is the bigger than a field of view. A standard calibration grid is available from FANUC in several sizes. It is strongly recommended that you order a calibration grid as well as a camera and lens.



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

1 Application Frame Setting

⇩

2 Camera Data Creation

⇩

3 Camera Setup

⇩

4 Calibration (Calibration Setup, Grid Frame Setup, Calibration)

⇩

5 Checking Calibration Point

⇩

6 Checking Calibration Result

For a robot system with multiple cameras, create camera data for each camera and perform calibration.

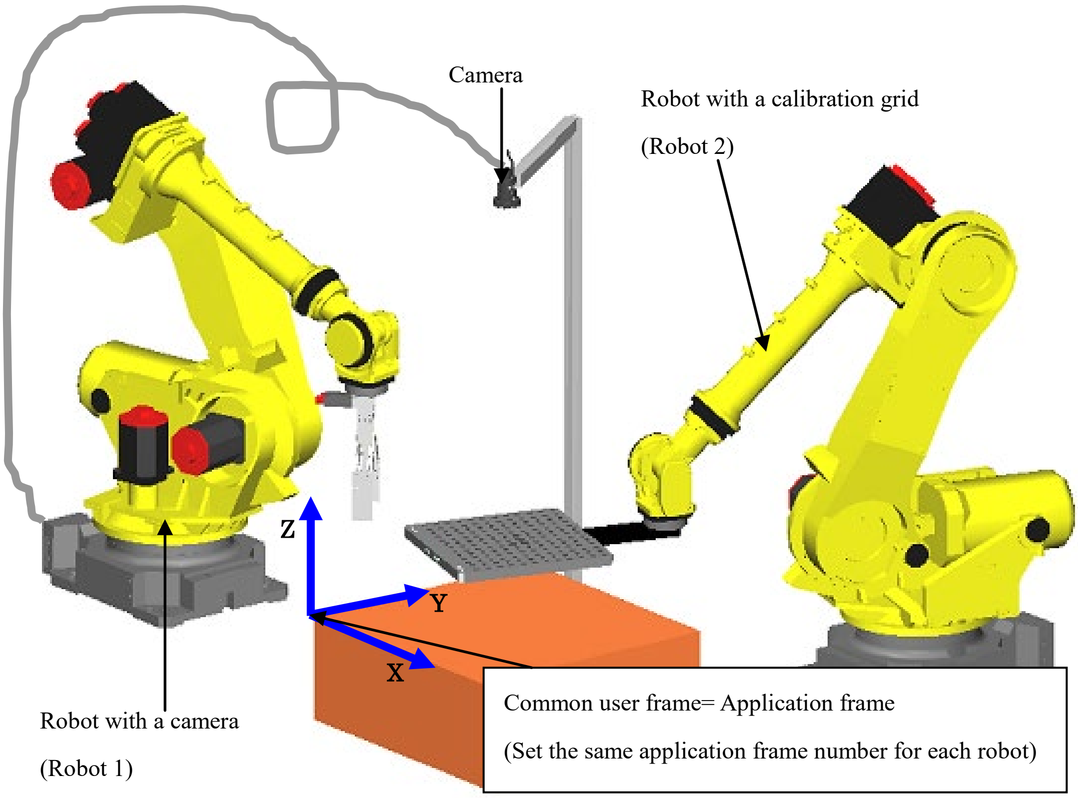
2.1.1 Application Frame Setting

Select a frame for the robot that will be the reference for calibration. Perform camera calibration using the selected frame as the reference.
User frame [0: World frame] is selected as the default setting. In most cases, it does not need to be changed. However, in the following cases, set up a user frame and perform calibration using that user frame number as the application frame.

- In cases where the camera is attached to a robot other than the robot to be offset
- In cases where the calibration grid is attached to a robot other than the robot to be offset
- In cases where multiple robots are to be compensated using the same offset

Also, in cases like the above, it is necessary to carry out communication between robot controllers. *i*RVision performs this communication when it is necessary, and for this, an interface function called 'ROS Interface Packet over Ethernet (RIPE)' is used internally. For robot systems to which the above cases apply, refer to the description of ROS Interface Packet over Ethernet (RIPE) in "Ethernet Function OPERATOR’S MANUAL B-82974EN" when setting up the RIPE functions.

The figure below is an example of a situation in which the calibration grid is attached to a robot other than the robot to be offset. When a camera is installed on the Robot 1 and a calibration grid is installed on the Robot 2, set a common user frame for both robots, and use the frame as the application frame. Also make the user frame number common.



Example of a situation in which the calibration grid is attached to a robot other than the robot to be offset

For information on user frame settings, refer to Know-how Edition Section 1, "FRAME SETTING".

2.1.2 Camera Data Creation

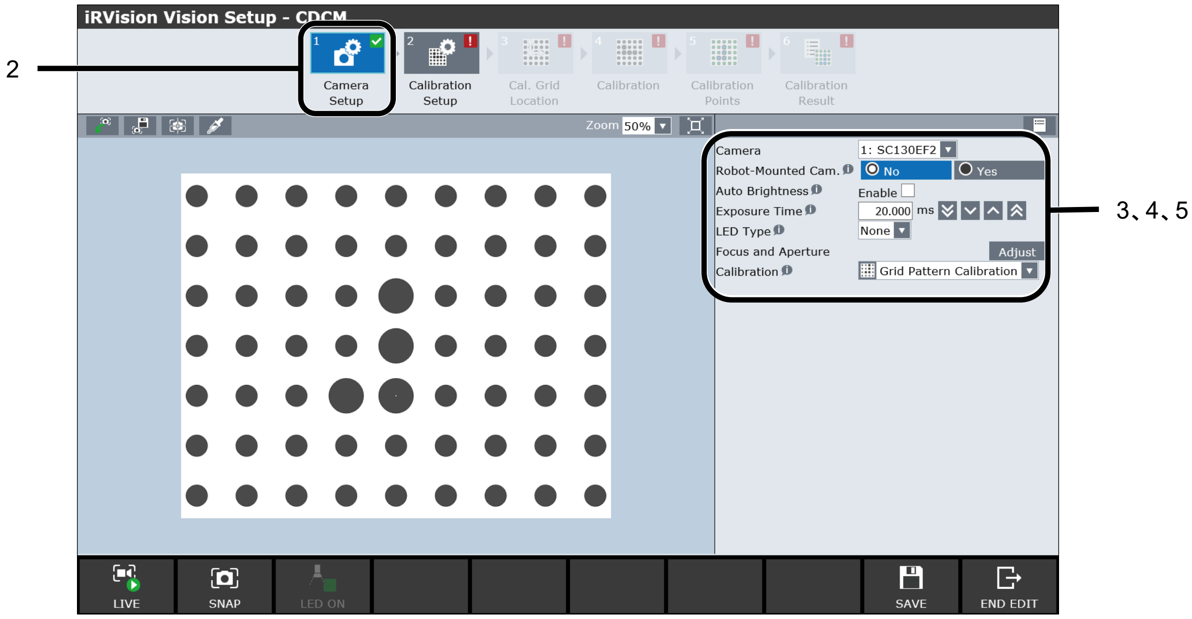
Create camera data for the 2D camera and set the camera type, method for camera installation, etc.

For details on the creation of vision tools, including camera data, refer to the description of creating new vision data in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.1.3 Camera Setup

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

1 On the vision data list screen, click the camera data that has been created.
2 Click [1. Camera Setup] in the navigation area.
A screen like the following one will appear.



3 Set the camera to use, the method for camera installation, the exposure time, the presence/absence of LED lighting, etc.
When use a fixed camera, select [No] for [Robot-Mounted Cam.].
4 Select [Grid Pattern Calibration] for [Calibration].
5 Adjust the diaphragm and focus of the lens. If you click [Adjust] in [Focus and Aperture], "Focus Adjustment Guide" is displayed. For details, refer to the description of the focus adjustment guide in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

> ⚠ **CAUTION**
> Adjust the diaphragm and focus of the lens before camera calibration. If the diaphragm and focus are readjusted, camera calibration needs to be performed again.

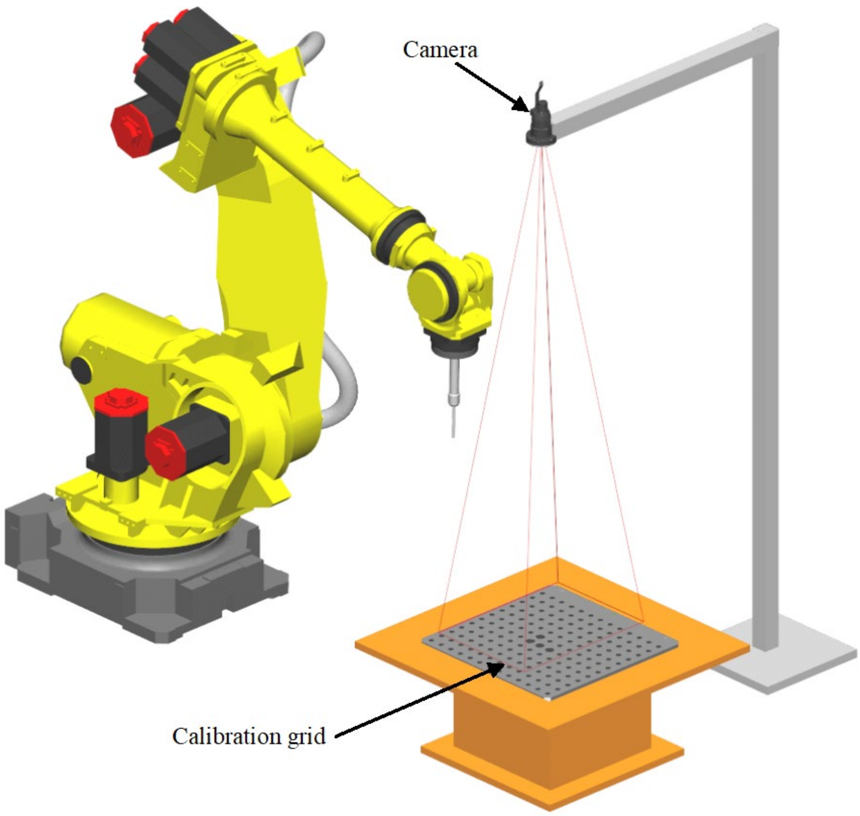
> **Memo**
> The brightness of images snapped with a camera that supports HDR can be adjusted automatically. For details, refer to the description of automatic brightness adjustment in "*i*RVision OPERATOR'S MANUAL (Reference)".

2.1.4 Calibration

Detect the grid pattern and perform camera calibration. The method for calibration varies depending on where the calibration grid is installed.
When using a fixed installation for the calibration grid, refer to Know-how Edition Subsection 2.1.4.1, "For fixed installation".
When installing the calibration grid on the robot's gripper, refer to Know-how Edition Subsection 2.1.4.2, "For robot-mounted installation".

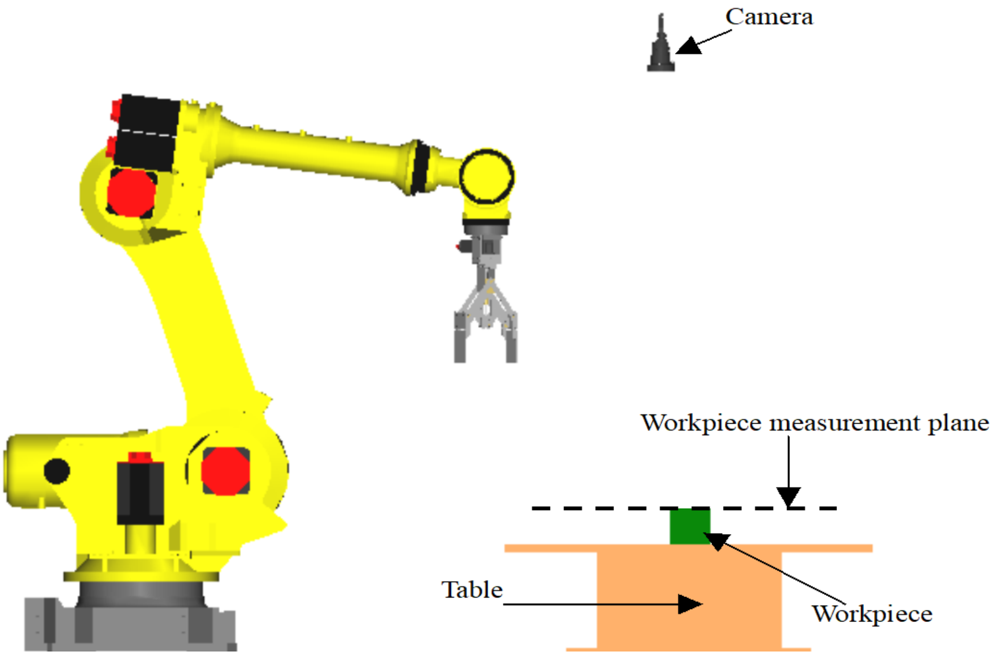
2.1.4.1 For fixed installation

When using a fixed installation for the calibration grid, perform calibration using one plane as shown in the figure below.



Example of using a fixed installation for the calibration grid

Also, when using a fixed installation for the calibration grid, it is recommended that you install the calibration grid near the workpiece detection plane. As shown in the figure below, it is recommended that you install the calibration grid at a position where the distance between the camera and the workpiece detection plane is the same as the distance between the camera and the calibration grid.



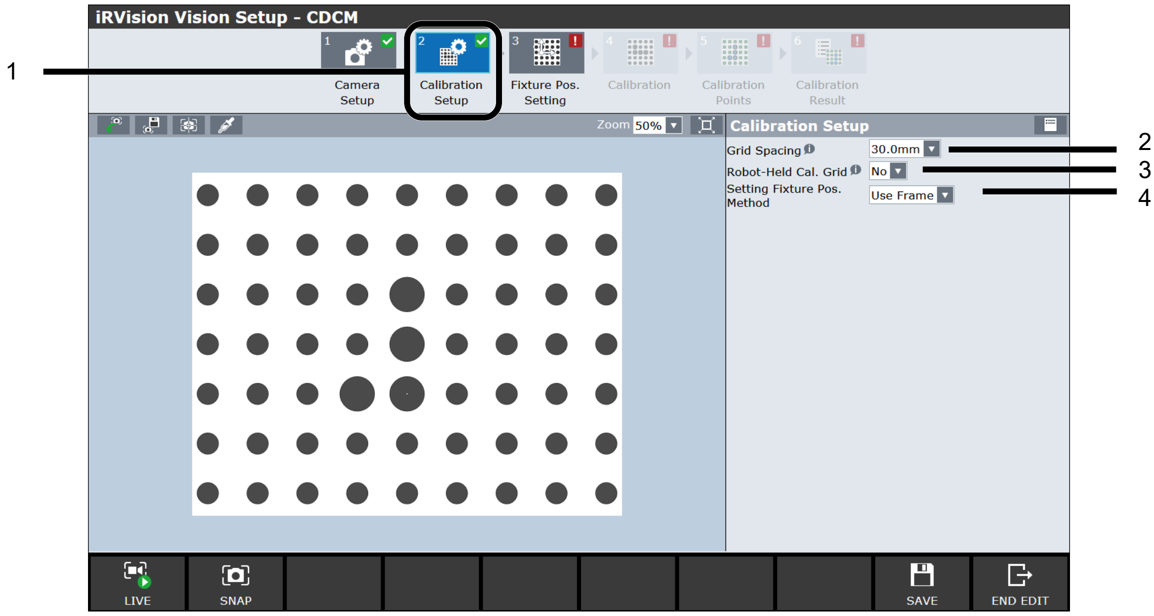
Installation plane of the calibration grid and workpiece detection plane

In the frame, set the information that says where the calibration grid is installed. In cases where calibration is performed with the calibration grid fixed to a table, etc., set the installation information for the calibration grid in a user frame with an arbitrary number. After setting the calibration grid position in the user frame, do not move the calibration grid until calibration is complete. There are two methods for setting a user frame: a method that uses a pointer tool, and a method that uses automatic grid frame set. For details on setting using touch-up, refer to Know-how Edition Subsection 1.1.1, "User Frame Setting". For details on setting using automatic grid frame set, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION".

Calibration Setting Procedure

Calibration setting for when using a fixed installation for the calibration grid is as follows.

1 Select [2 Calibration Setup] in the navigation area.
The grid pattern calibration setup screen will appear.



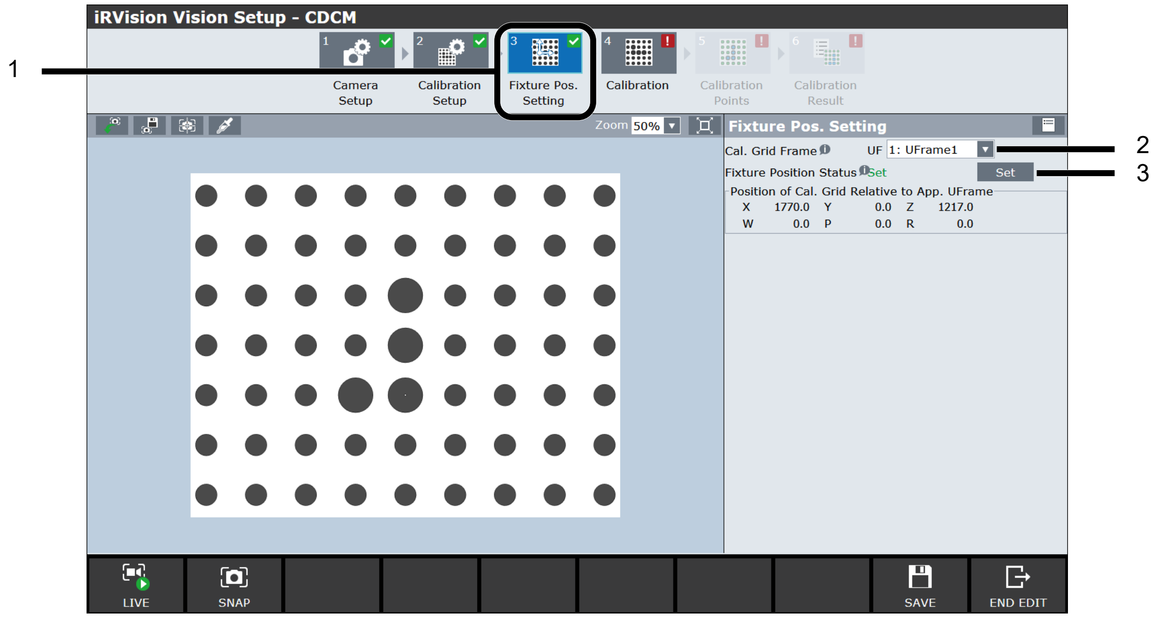
2 From the [Grid Spacing] drop-down box, select the grid spacing for the calibration grid.
3 From the [Robot-Held Cal. Grid] drop-down box, select [No].
4 From the [Setting Fixture Pos. Method] drop-down box, select [Use Frame].

> **Memo**
> In the simple mode, the world frame is set as the application frame. To change the application frame to another user frame, switch to the advanced mode and change the application frame.

Grid Frame Setting Procedure

The procedure to set the position of the calibration grid when fixing the calibration grid is as follows.

1 Select [3 Fixture Pos. Setting] in the navigation area.
The screen to set the fixture position of the calibration grid appears.



2 From the [Cal. Grid Frame] drop-down box, select the user frame number where the position of the calibration grid is registered.

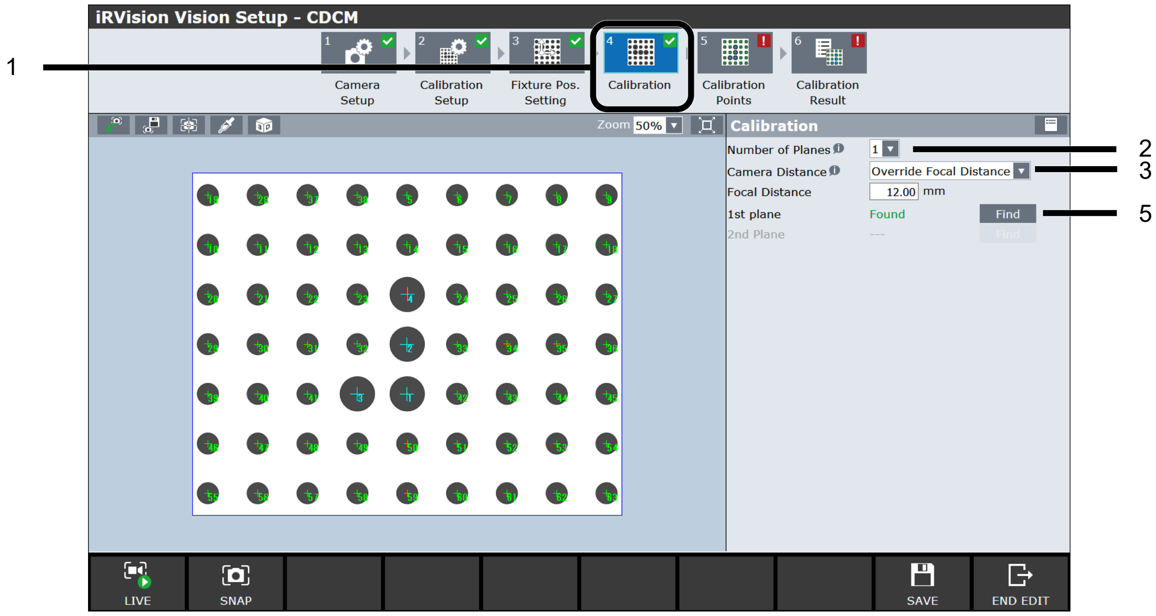
Memo
Note that the frame specified in [Cal. Grid Frame] is different from [Application Frame] and [Offset Frame].

3 Click the [Set] button in [Fixture Position Status].
The position registered in the set user frame number is displayed in [Position of Cal. Grid Relative to App. UFrame].

Calibration Execution Procedure

The procedure to execute grid pattern calibration when fixing the calibration grid is as follows.

1 Select [4 Calibration] in the navigation area.
The screen to set grid pattern calibration appears.



2 From the [Number of Planes] drop-down box, select [1].
When the calibration grid is fixed, one plane is used for calibration.

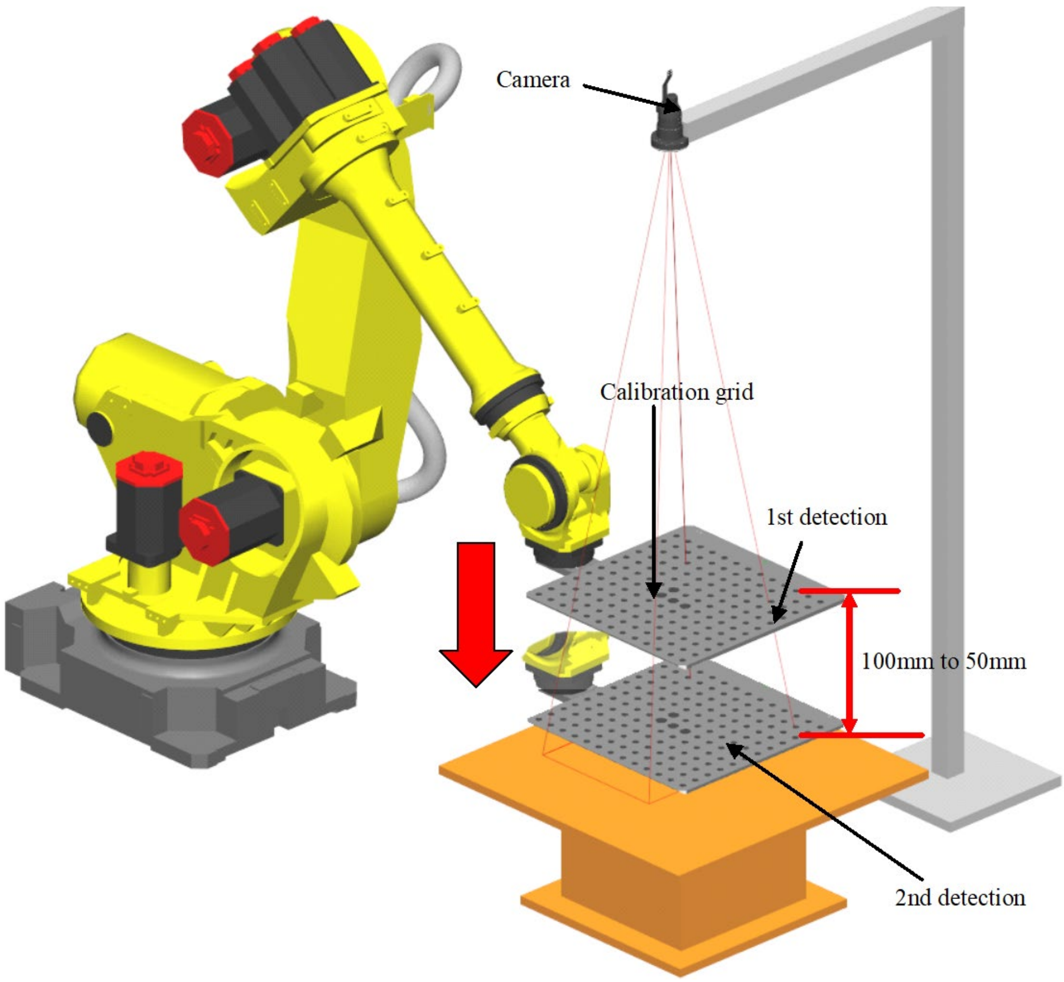
3 From the [Camera Distance] drop-down box, select [Override Focal Distance] and enter the nominal focal distance of the lens in the text box.
When one plane was used for calibration with the calibration grid mounted perpendicular to the optical axis of the camera, a correct focal distance cannot be theoretically calculated. Therefore, manually enter the focal distance of the lens after finding the calibration grid. For example, when the focal distance of your lens is 12 mm, enter "12.0".

4 Click [SNAP] to capture the image of the calibration grid.

5 Click the [Find] button in [1st plane].
For details on the setting after finding the image, refer to Know-how Edition Subsections 2.1.5, "Checking Calibration Point" and 2.1.6, "Checking Calibration Result".

2.1.4.2 For robot-mounted installation

When installing the calibration grid on the robot's gripper, perform calibration using two planes by moving the robot vertically as shown in the figure below.



Example of calibration using two planes when installing a calibration grid on the robot's gripper

- In the 2D Single-view Vision Process or 2D Multi-view Vision Process, the up/down distance for two-plane calibration should be 100 to 150 mm. It is recommended that the distance between the camera and the calibration grid for one of the planes is the same as the distance between the camera and the workpiece.
- In the Depalletizing Vision Process, it is recommended that the up/down distance for two-plane calibration be set to a value that covers the upper and lower ends of the workpiece in the pallet.
- In the 3D Tri-View Vision Process, perform detection by bringing calibration surface 1 as close as possible to the detection target. In addition, the up/down distance for two-plane calibration should be 100 to 150 mm.

Find the grid pattern at two different heights. When moving the calibration grid up and down, jog the robot without changing the calibration grid posture. Make sure that the calibration grid is fixed securely to the robot end of arm tooling so that it remains in place while the robot moves. It is recommended that positioning pins or other appropriate means may be used so that the calibration grid can be mounted at the same position.

For the robot-mounted installation, there are the following three methods to acquire the fixture position of the calibration grid. It is recommended that you should use the method to automatically measure the position of the calibration grid on the camera data edit screen.

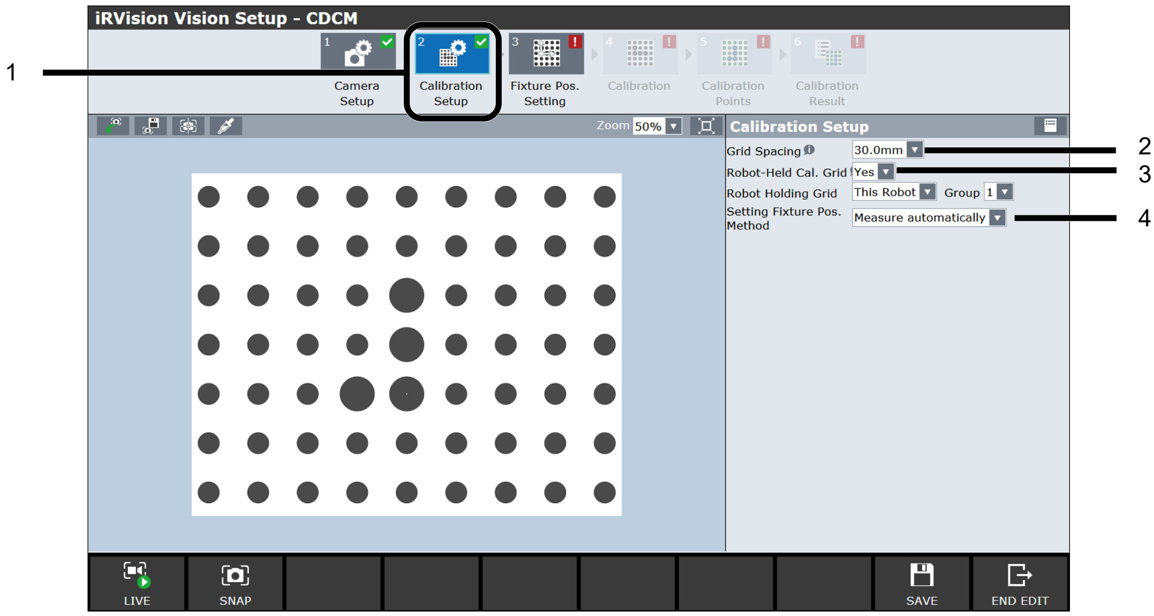
- Method to open the camera data edit screen from the teach pendant and automatically measure the position of the calibration grid
- Method to use a pointer tool
- Method to use the grid frame setting function from [iRVision utility] on the teach pendant

For methods to use a pointer tool and the grid frame setting, set the position of the calibration grid to the tool frame. For details on setting using touch-up, refer to Know-how Edition Subsection 1.1.2, "Tool Frame". For details on setting using automatic grid frame set, refer to Know-how Edition Section 1.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION".

Calibration Setting Procedure

Calibration setting for when installing the calibration grid on the robot's gripper is as follows.

1 Select [2 Calibration Setup] in the navigation area.
The grid pattern calibration setup screen will appear.



2 From the [Grid Spacing] drop-down box, select the grid spacing for the calibration grid.
3 From the [Robot-Held Cal. Grid] drop-down box, select [Yes].
4 From the [Setting Fixture Pos. Method] drop-down box, select [Measure automatically].

Memo

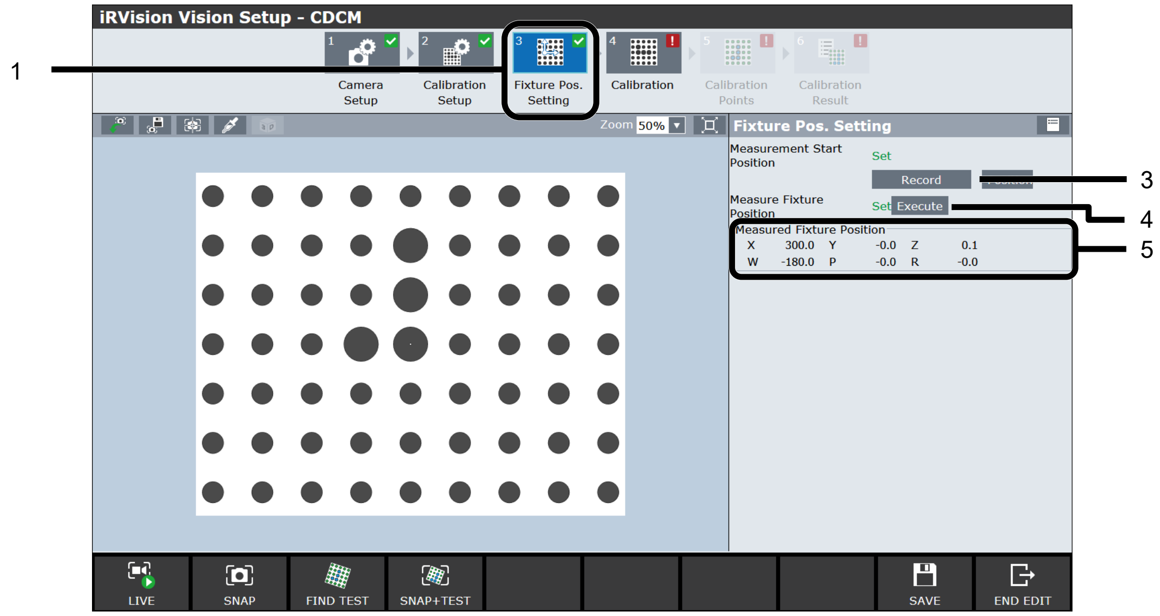
1 In the simple mode, the world frame is set as the application frame. To change the application frame to another user frame, switch to the advanced mode and change the application frame.
2 If the position of the calibration grid was set to the tool frame using a pointer tool or the grid frame setting, select [Use Frame] from the [Setting Fixture Pos. Method] drop-down box.

Grid Frame Setting Procedure

The procedure to automatically measure the position of the calibration grid when attaching the camera to the robot end of arm tooling is as follows.

For details, refer to Know-how Edition Subsection 1.2.1, "Setting Procedure from the Camera Data Edit Screen".

1 Open the camera data edit screen from the teach pendant and select [3 Fixture Pos. Setting] in the navigation area.
The screen to set the fixture position of the calibration grid appears.



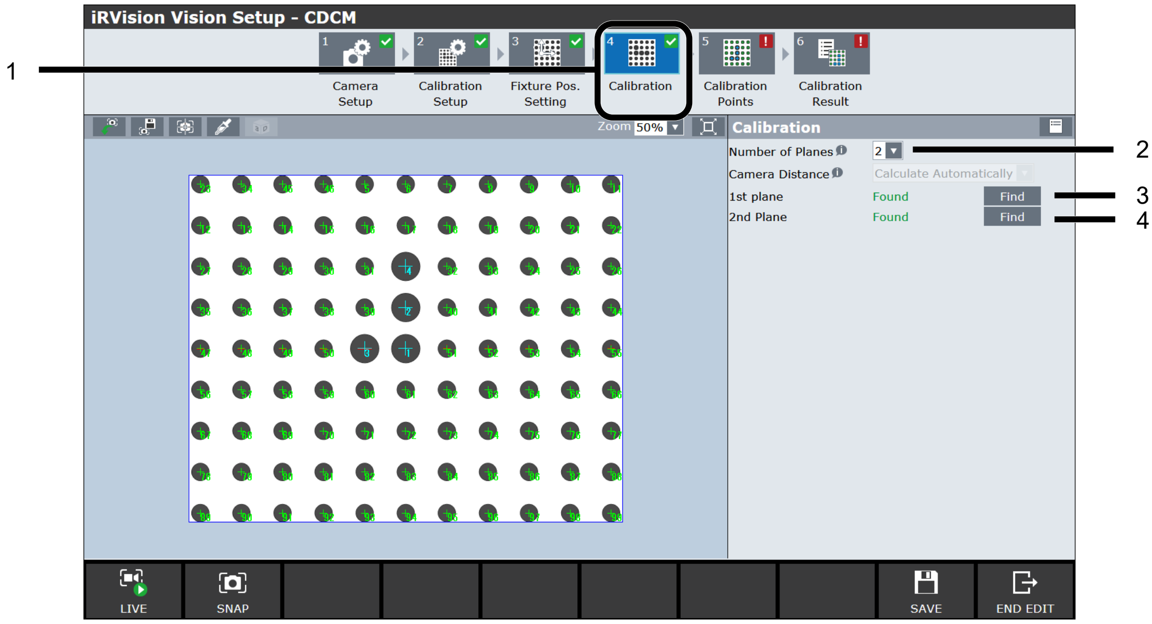
2 Jog the robot to the automatic measurement start position.
The measurement start position must have a distance so that the camera faces the center of the calibration grid almost straight and comes into focus.
3 Click the [Record] button in [Measurement Start Position].
[Set] is displayed in [Measurement Start Position].
4 Click the [Execute] button in [Measure Fixture Position] while holding down the [SHIFT] key on the teach pendant.
When the measurement is successfully completed, the completion message pops up.
5 Check if the position displayed in [Measured Fixture Position] is correct.

Memo
If the position of the calibration grid was set to the tool frame using a pointer tool or the grid frame setting, use the same procedure as for the grid frame setting procedure in Know-how Edition Subsection 2.1.4.1, "For fixed installation". In that case, set the tool frame number in [Cal. Grid Frame].

Calibration Execution Procedure

The procedure to execute grid pattern calibration when attaching the calibration grid to the robot end of arm tooling is as follows.

1 Select [4 Calibration] in the navigation area.
The screen to set grid pattern calibration appears.



2 From the [Number of Planes] drop-down box, select [2].
When the calibration grid is attached to the robot end of arm tooling, two planes are used for calibration.

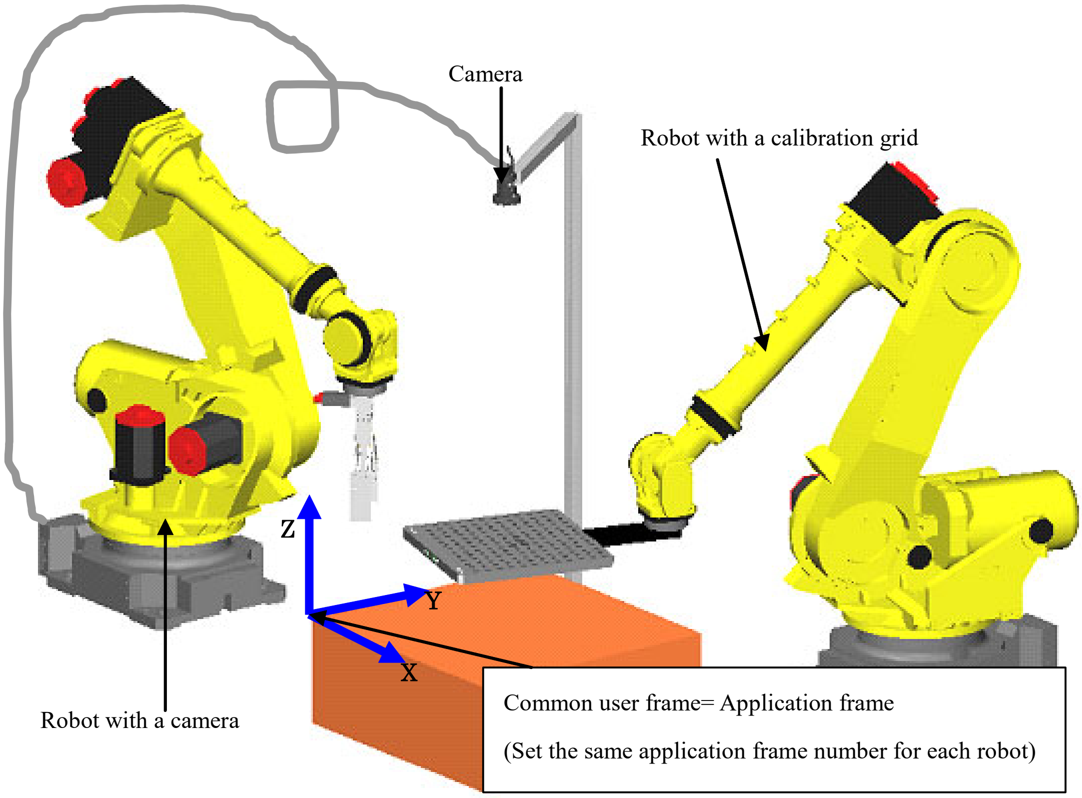
3 Find the 1st Plane. Move the calibration grid an appropriate distance from the camera, click [SNAP], and click the [Find] button in [1st plane].

4 Find the 2nd Plane. Change the distance between the calibration grid and the camera, click [SNAP], and click the [Find] button in [2nd Plane].

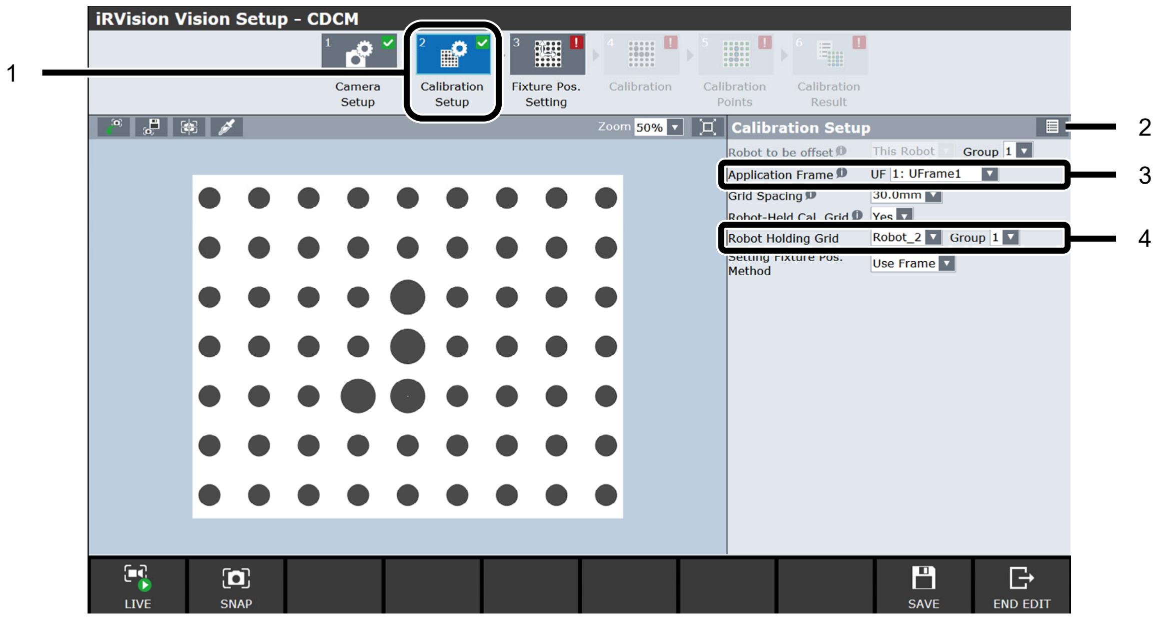
For details on the setting after finding the image, refer to Know-how Edition Subsections 2.1.5, "Checking Calibration Point" and 2.1.6, "Checking Calibration Result".

2.1.4.3 When two or more robots are used

If the robot that has a camera attached to it and the robot that has a calibration grid attached to it are different as shown in the figure below, for the [Robot Holding Grid], select the robot controller for the robot with the calibration grid attached to it on the teaching screen for calibration.



Example of a situation in which the calibration grid is attached to a robot other than the robot to be offset

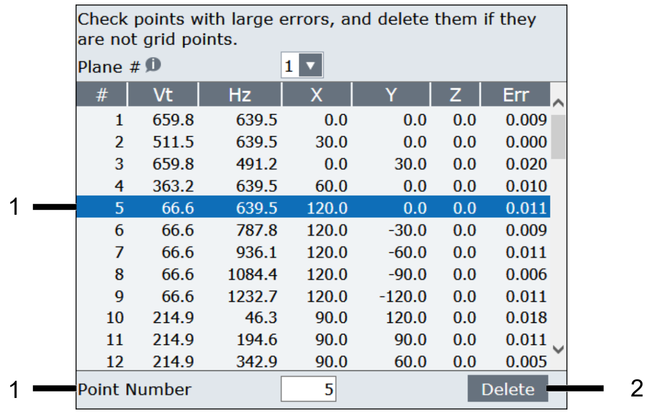


1 Click [2 Calibration Setup] in the navigation area.
2 Click the icon to switch to the advanced mode.
3 From the [Application Frame] drop-down box, select a frame for the robot that will be the reference for calibration. Specify the same user frame number for the two robots.
4 From the [Robot Holding Grid] drop-down box, select the name of the robot controller for the robot with the calibration grid attached to it, and the motion group number.

2.1.5 Checking Calibration Point

Check the calibration point found in Know-how Edition Subsection 2.1.4, [Calibration].
If you click [5 Calibration Points] in the navigation area, the calibration points screen will appear.

2



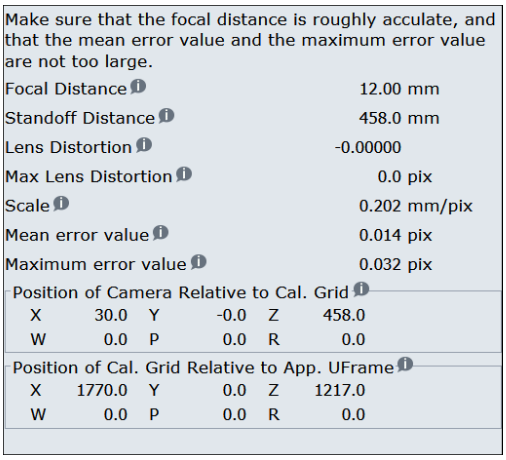
#	Vt	Hz	X	Y	Z	Err
1	659.8	639.5	0.0	0.0	0.0	0.009
2	511.5	639.5	30.0	0.0	0.0	0.000
3	659.8	491.2	0.0	30.0	0.0	0.020
4	363.2	639.5	60.0	0.0	0.0	0.010
5	66.6	639.5	120.0	0.0	0.0	0.011
6	66.6	787.8	120.0	-30.0	0.0	0.009
7	66.6	936.1	120.0	-60.0	0.0	0.011
8	66.6	1084.4	120.0	-90.0	0.0	0.006
9	66.6	1232.7	120.0	-120.0	0.0	0.011
10	214.9	46.3	90.0	120.0	0.0	0.018
11	214.9	194.6	90.0	90.0	0.0	0.011
12	214.9	342.9	90.0	60.0	0.0	0.005

If there are points found other than the dot positions of the calibration grid, delete the irrelevant found points using the following procedure.

1 Select an irrelevant found point from the found point list, or enter a found point number in the [Point Number] text box.
2 Click the [DELETE] button.
The irrelevant found point will be deleted.

2.1.6 Checking Calibration Result

Check the calculated calibration data.
If you click [6 Calibration Result] in the navigation area, a calibration result screen like the following one will appear.



[Scale] indicates how many mm one pixel on an image is equivalent to. It can be calculated by dividing the size of field of view by the image size.

Example:
If the size of field of view is 262×169 mm and the image size is 640×480 pix, the scale will be as follows.

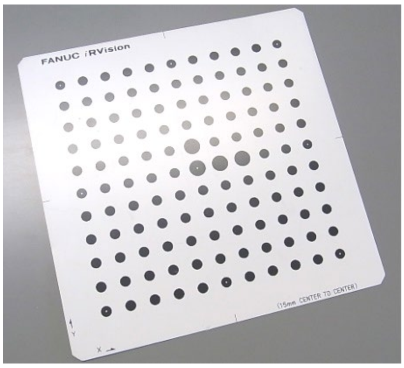
0.409 mm/pix = 262 mm ÷ 640 pix

If there is a large error in the [Scale], check whether the installation information for the calibration grid has been correctly set, and the [Grid Spacing] has been correctly input. [Scale] changes depending on the distance from the camera, so it will not be constant within the field of view. The displayed value for [Scale] is an average value for near the calibration plane.

If there is no problem with the calibration points and calibration result, then the calibration is complete.
Click [SAVE] to save the data, then click [END EDIT].
The calibration grid can now be removed.

2.2 GRID PATTERN CALIBRATION WITH A ROBOT-MOUNTED CAMERA

Grid pattern calibration is a general-purpose calibration method for cameras that uses a special jig called a calibration grid. When using grid pattern calibration, prepare a calibration grid in advance. Usually, prepare a calibration grid which is the bigger than a field of view. A standard calibration grid is available from FANUC in several sizes. It is strongly recommended that you order a calibration grid as well as a camera and lens.



It is not necessary to detect all the dots on the calibration grid. There are 11×11 dots in the standard calibration grid of FANUC. If 7×7 dots are detected, the camera calibration is performed with sufficient accuracy. (The four big dots need to be detected.) In order to show all the dots in field of view, it is not necessary to prepare a small calibration grid. In order to perform a calibration with accuracy sufficient to the edge of the field of view, even if the number of detectable dots became fewer, prepare the bigger calibration grid than a field of view.
Use the following setup procedure for 'GRID PATTERN CALIBRATION WITH A ROBOT-MUONTED CAMERA' :

1 Application Frame Setting

⇩

2 Camera Data Creation

⇩

3 Camera Setup

⇩

4 Calibration (Calibration Setup, Grid Frame Setup, Calibration)

⇩

5 Checking Calibration Point

⇩

6 Checking Calibration Result

2.2.1 Application Frame Setting

Select a frame for the robot that will be the reference for calibration. Perform camera calibration using the selected frame as the reference.
User frame [0: World frame] is selected as the default setting. In most cases, it does not need to be changed. However, in the following cases, set up a user frame and perform calibration using that user frame number as the application frame.

- In cases where the camera is attached to a robot other than the robot to be offset
- In cases where the calibration grid is attached to a robot other than the robot to be offset
- In cases where multiple robots are to be compensated using the same offset

Also, in cases like the above, it is necessary to carry out communication between robot controllers. *i*RVision performs this communication when it is necessary, and for this, an interface function called 'ROS Interface Packet over Ethernet (RIPE)' is used internally. For robot systems to which the above cases apply, refer to the description of ROS Interface Packet over Ethernet (RIPE) in "Ethernet Function OPERATOR’S MANUAL B-82974EN" when setting up the RIPE functions.

2.2.2 Camera Data Creation

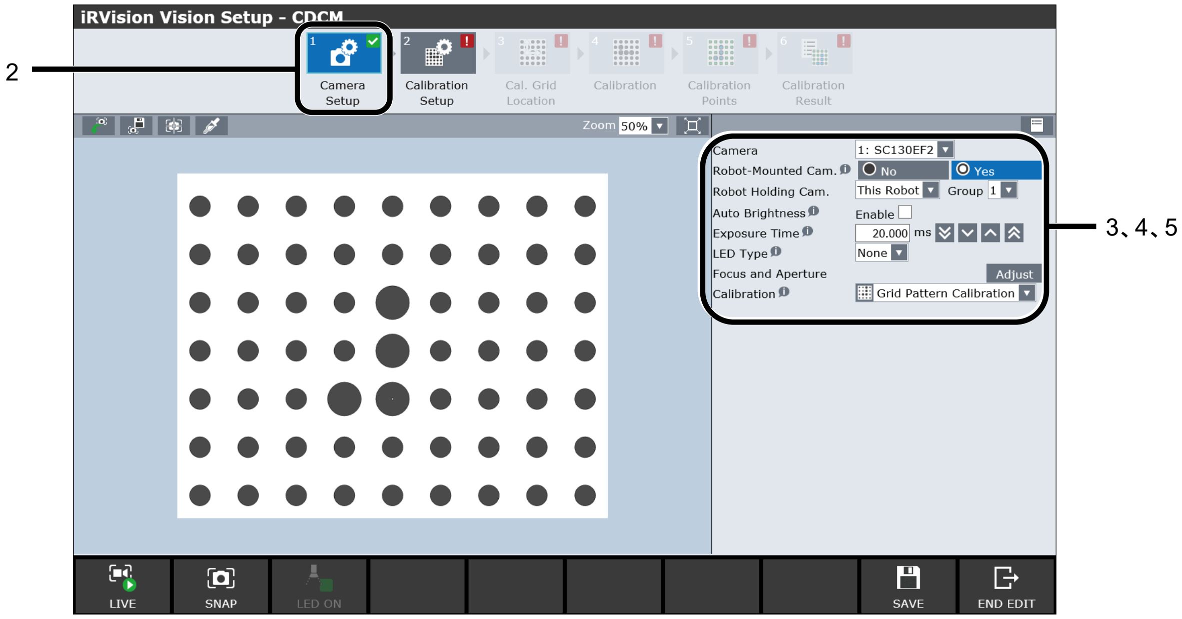
Create camera data for the 2D camera and set the camera type, method for camera installation, etc.

For details on the creation of vision tools, including camera data, refer to the description of creating new vision data in the "*i*RVision OPERATOR’S MANUAL (Reference) B-83914EN".

2.2.3 Camera Setup

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

1 On the vision data list screen, click the camera data that has been created.
2 Click [1 Camera Setup] in the navigation area.
  A screen like the following one will appear.



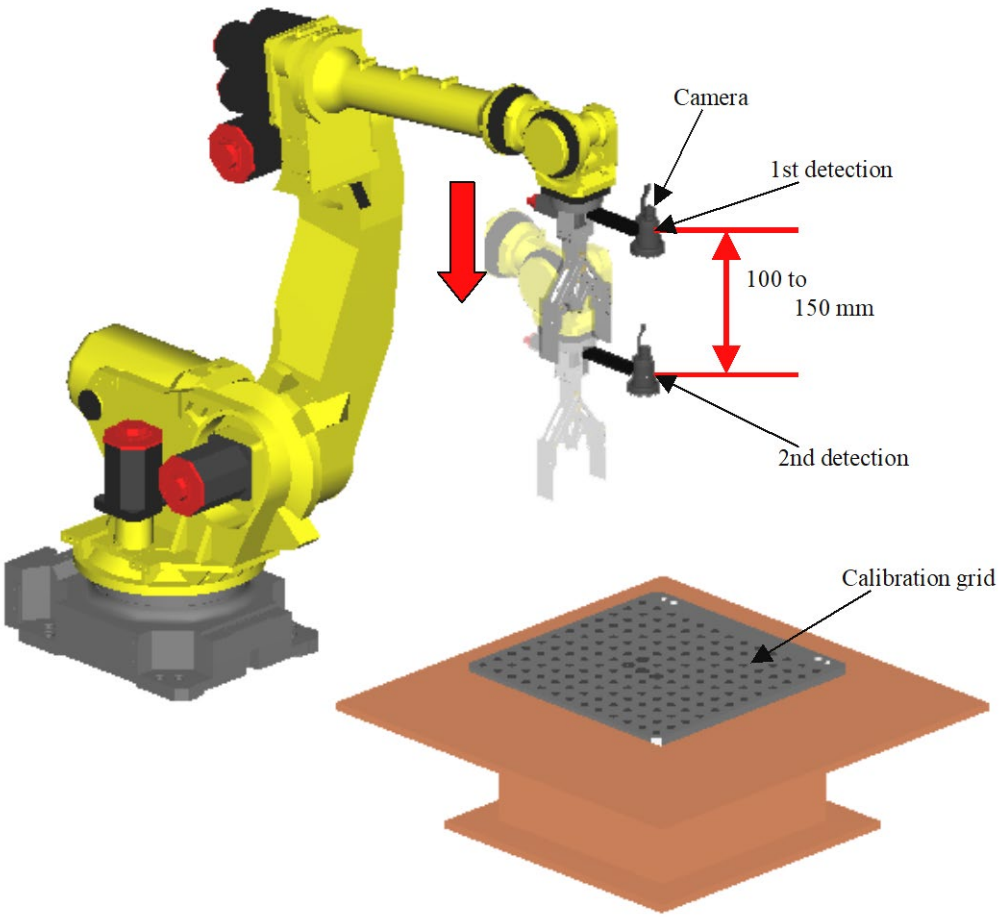
3 Set the camera to use, the method for camera installation, the exposure time, the presence/absence of LED lighting, etc.
If a camera has been attached to the robot's hand, select [Yes] for [Robot-Mounted Cam].
4 Select [Grid Pattern Calibration] for [Calibration].
5 Adjust the diaphragm and focus of the lens. If you click [Adjust] in [Focus and Aperture], "Focus Adjustment Guide" is displayed. For details, refer to the description of the focus adjustment guide in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

> ⚠ **CAUTION**
> Adjust the diaphragm and focus of the lens before camera calibration. If the diaphragm and focus are readjusted, camera calibration needs to be performed again.

> **Memo**
> The brightness of images snapped with a camera that supports HDR can be adjusted automatically. For details, refer to the description of automatic brightness adjustment in "*i*RVision OPERATOR'S MANUAL (Reference)".

2.2.4 Calibration

Detect the grid pattern and perform camera calibration.
If a camera has been attached to the robot's gripper, perform calibration using two planes by moving the robot vertically as shown in the figure below.



Example of two-plane calibration when installing a camera on the robot's gripper

- In the 2D Single-view Vision Process, 2D Multi-view Vision Process or, in the 3D Tri-View Vision Process, the up/down distance for two-plane calibration should be 100 to 150 mm. It is recommended that the distance between the camera and the calibration grid for one of the planes is the same as the distance between the camera and the workpiece.
- In the Depalletizing Vision Process, it is recommended that the up/down distance for two-plane calibration be set to a value that covers the upper and lower ends of the workpiece in the pallet.

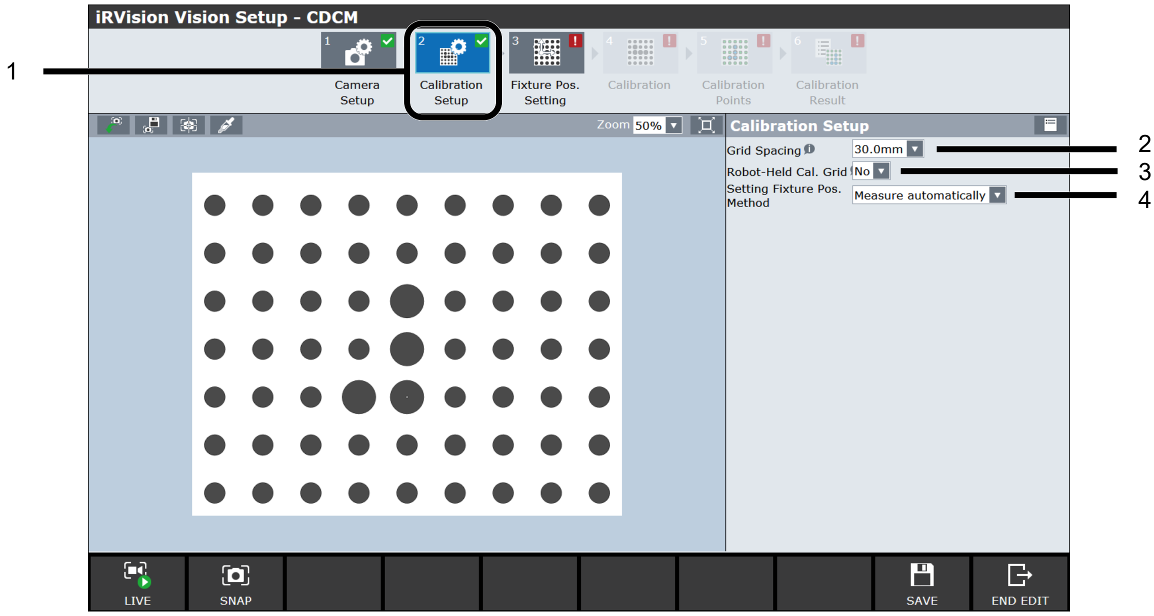
Find the calibration grid at two different heights. In this operation, ensure that the posture of the robot for detecting the calibration grid is the same as the posture for detecting a workpiece. When moving the camera up and down, jog the robot without changing the camera posture.

For calibration with the calibration grid fixed to a table, the fixture position of the calibration grid is normally calculated automatically on the camera data edit screen before calibration.

Calibration Setting Procedure

The calibration setting for when a camera is attached to the robot's gripper is as follows.

1 Click [2 Calibration Setup] in the navigation area.
The grid pattern calibration setup screen will appear.



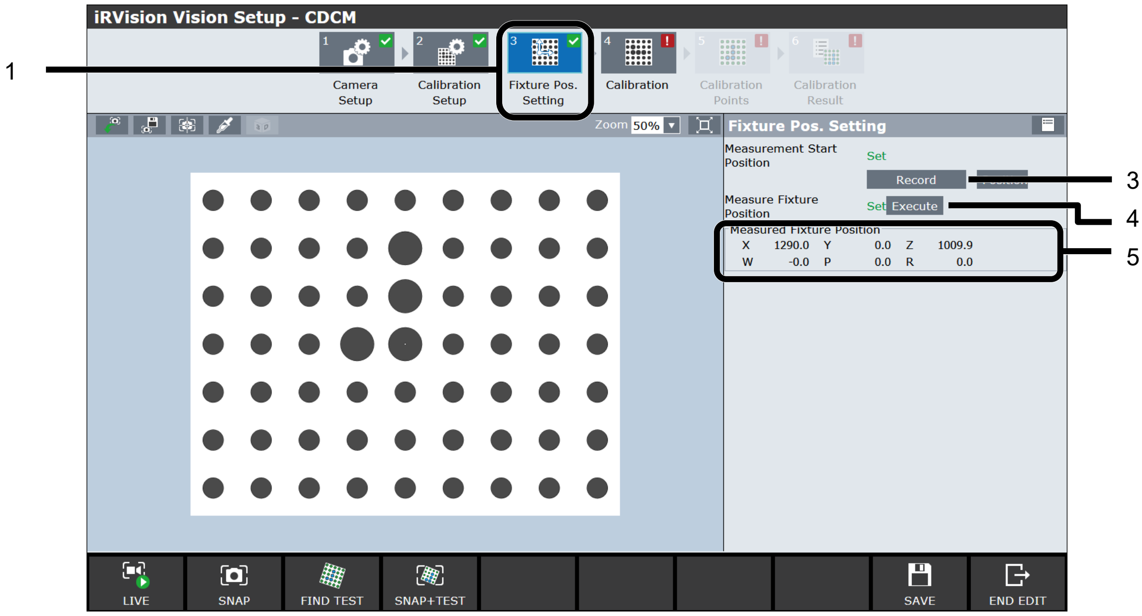
2 From the [Grid Spacing] drop-down box, select the grid spacing for the calibration grid.
3 From the [Robot-Held Cal. Grid] drop-down box, select [No].
4 From the [Setting Fixture Pos. Method] drop-down box, select [Measure automatically].

Memo
In the simple mode, the world frame is set as the application frame. To change the application frame to another user frame, switch to the advanced mode and change the application frame.

Grid Frame Setting Procedure

The procedure to automatically measure the position of the calibration grid when attaching the camera to the robot end of arm tooling is as follows.
For details, refer to Know-how Edition Subsection 1.2.1, "Setting Procedure from the Camera Data Edit Screen".

1 Open the camera data edit screen from the teach pendant and select [3 Fixture Pos. Setting] in the navigation area.
The screen to set the fixture position of the calibration grid appears.



2 Jog the robot to the automatic measurement start position.
The measurement start position must have a distance so that the camera faces the center of the calibration grid almost straight and comes into focus.

3 Click the [Record] button in [Measurement Start Position].
[Set] is displayed in [Measurement Start Position].

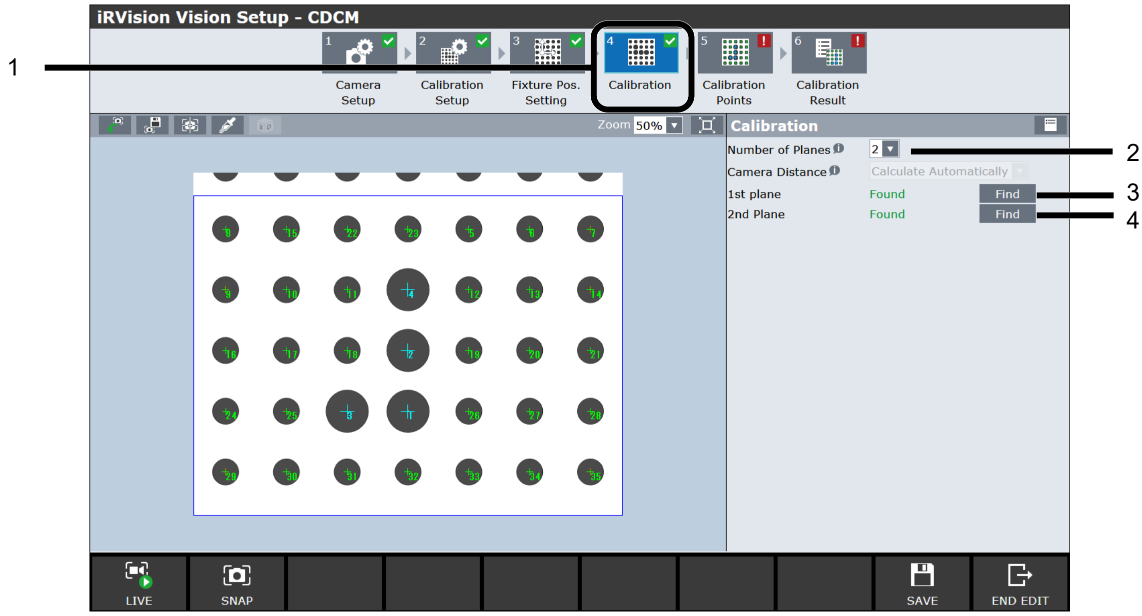
4 Click the [Execute] button in [Measure Fixture Position] while holding down the [SHIFT] key on the teach pendant.
When the measurement is successfully completed, the completion message pops up.

5 Check if the position displayed in [Measured Fixture Position] is correct.

Calibration Execution Procedure

The procedure to execute grid pattern calibration when attaching the camera to the robot end of arm tooling is as follows.

1 Select [4 Calibration] in the navigation area.
The screen to set grid pattern calibration appears.



2 From the [Number of Planes] drop-down box, select [2].

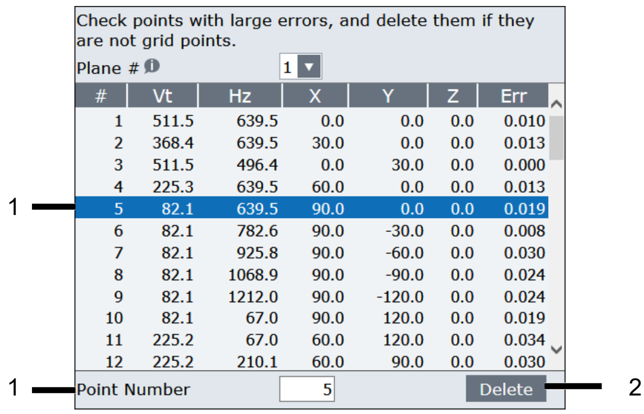
3 Find the 1st Plane. Move the calibration grid an appropriate distance from the camera, click [SNAP], and click the [Find] button in [1st plane].

4 Find the 2nd Plane. Change the distance between the calibration grid and the camera, click [SNAP], and click the [Find] button in [2nd Plane].

For details on the setting after finding the image, refer to Know-how Edition Subsections 2.1.5, "Checking Calibration Point" and 2.1.6, "Checking Calibration Result".

2.2.5 Checking Calibration Point

Check the calibration point found in Know-how Edition Subsection 2.2.4, "Calibration".
Click [Calibration Points] in the navigation area. A calibration point screen like the following will appear.



#	Vt	Hz	X	Y	Z	Err
1	511.5	639.5	0.0	0.0	0.0	0.010
2	368.4	639.5	30.0	0.0	0.0	0.013
3	511.5	496.4	0.0	30.0	0.0	0.000
4	225.3	639.5	60.0	0.0	0.0	0.013
5	82.1	639.5	90.0	0.0	0.0	0.019
6	82.1	782.6	90.0	-30.0	0.0	0.008
7	82.1	925.8	90.0	-60.0	0.0	0.030
8	82.1	1068.9	90.0	-90.0	0.0	0.024
9	82.1	1212.0	90.0	-120.0	0.0	0.024
10	82.1	67.0	90.0	120.0	0.0	0.019
11	225.2	67.0	60.0	120.0	0.0	0.034
12	225.2	210.1	60.0	90.0	0.0	0.030

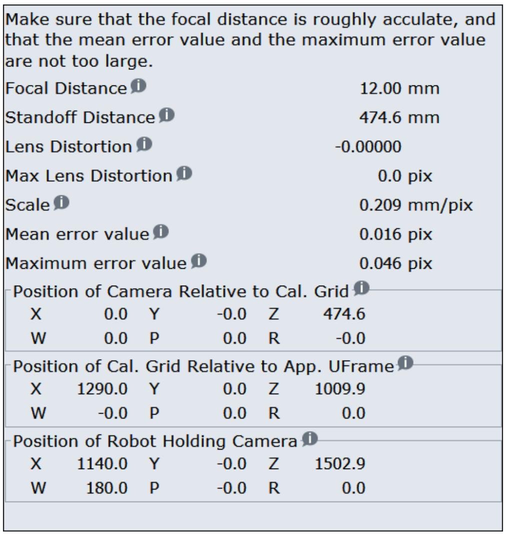
If there are points found other than the dot positions of the calibration grid, delete the irrelevant found points using the following procedure.

1 Select an irrelevant found point from the found point list, or enter a found point number in the [Point Number] text box.

2 Click the [DELETE] button to delete the irrelevant found point.

2.2.6 Checking Calibration Result

Check the calculated calibration data.
If you click [Calibration Result] in the navigation area, a calibration result screen like the following will appear.



[Scale] indicates how many mm one pixel on an image is equivalent to. It can be calculated by dividing the size of field of view by the image size.

Example:
If the size of field of view is 262×169 mm and the image size is 640×480 pix, the scale will be as follows.

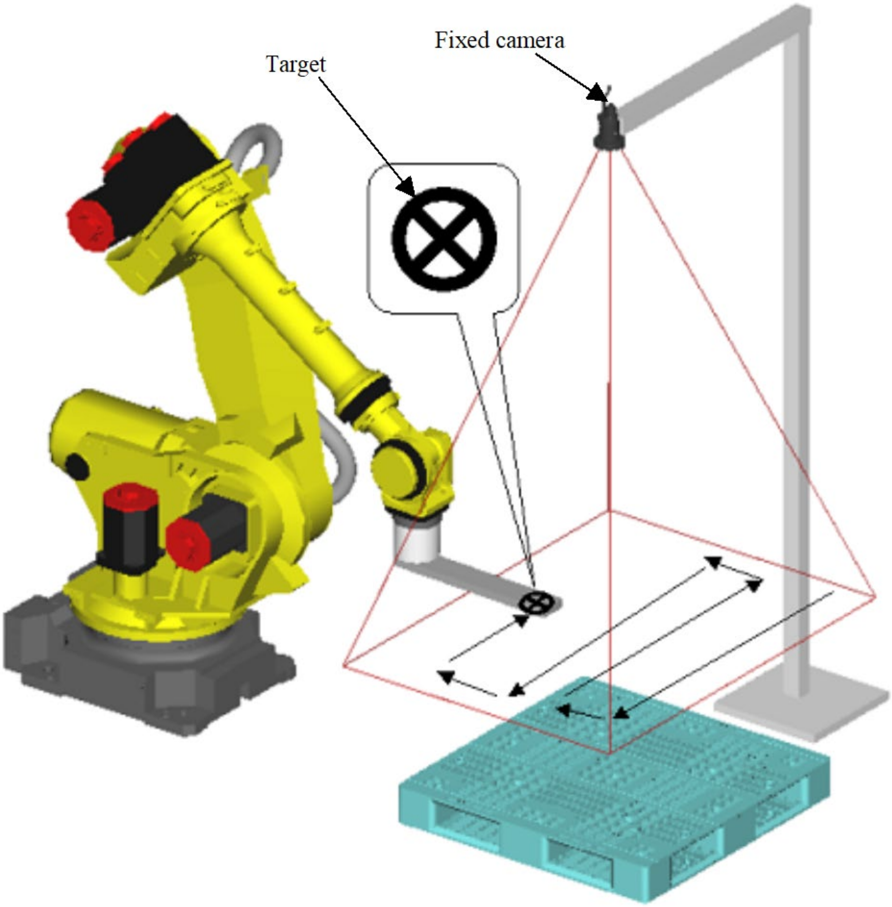
0.409 mm/pix = 262 mm ÷ 640 pix

If there is a large error in the [Scale], check whether the installation information for the calibration grid has been correctly set, and the [Grid Spacing] has been correctly input. [Scale] changes depending on the distance from the camera, so it will not be constant within the field of view. The displayed value for [Scale] is an average value for near the calibration plane.

If there is no problem with the calibration points and calibration result, then the calibration is complete.
Click [SAVE] to save the data, then click [END EDIT].
The calibration grid can now be removed.

2.3 ROBOT-GENERATED GRID CALIBRATION

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



Example of a layout for robot-generated grid calibration

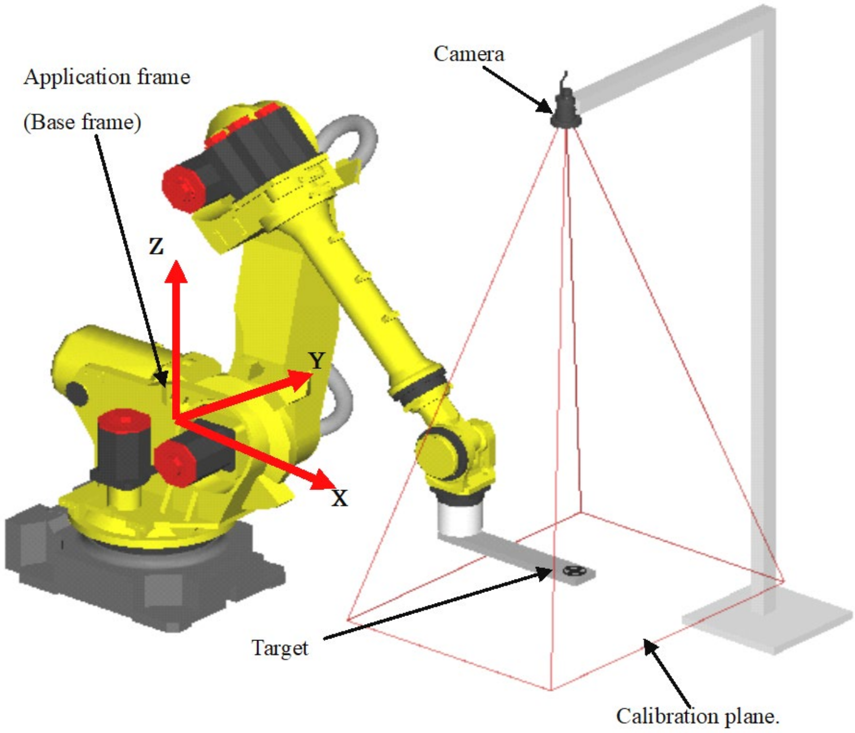
Set up robot-generated grid calibration using the following procedure.

1 Application Frame Setting
↓
2 Selecting and Mounting the Target
↓
3 Camera Data Creation
↓
4 Camera Setup
↓
5 Calibration Setup
↓
6 Teaching Model
↓
7 Executing Calibration
↓
8 Checking Calibration Point
↓
9 Checking Calibration Result

If the target can be mounted in the same position each time using positioning pins, the previously created re-calibration program can be used again for re-calibration. In this case, re-calibration of the camera can be performed by executing this program from the first line.
For details on robot-generated grid calibration, refer to the description of Robot-Generated Grid Calibration in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

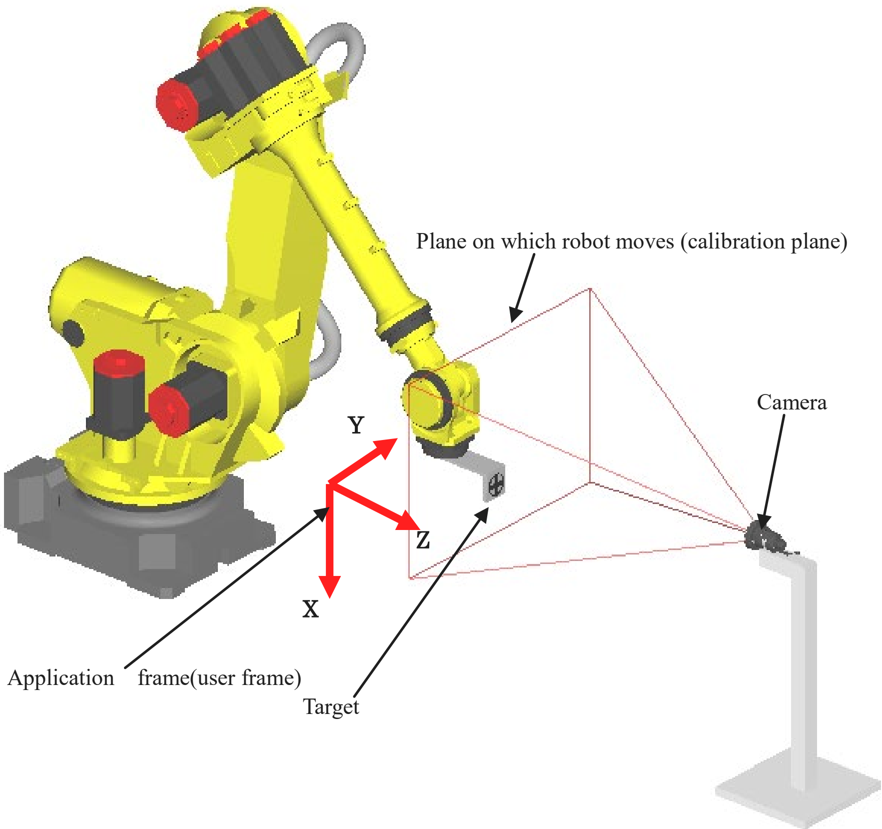
2.3.1 Application Frame Setting

Select a frame for the robot that will be the reference for calibration. Perform camera calibration using the selected frame as the reference.
Set an application frame so that the XY plane of the application frame is almost parallel with the calibration plane. During camera calibration, the robot moves in parallel to the XY plane of the application frame. As shown in the figure below, if the calibration plane and the XY plane of the world frame are almost parallel, a user frame [0: World frame] can also be selected as the application frame.



Calibration plane and world frame

As shown below, set a user frame so that the XY plane of the user frame is parallel with the calibration plane. A user frame number is arbitrary, and use this user frame number as the application frame number.



Calibration plane and user frame

2.3.2 Selecting and Mounting the Target

Select the target mark to be used for calibration.

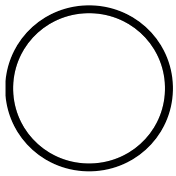
Geometry of the target

The target must meet the following conditions:

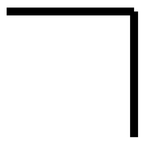
- The features to be taught are on the same one plane.
- The target has a geometry for which any rotation of ±45° or so can be identified.
- The target has a geometry whose size can be identified.

Below are examples of appropriate/inappropriate shapes for the target.

Examples of appropriate shapes for the target



The rotation angle cannot be identified.



The size cannot be identified.

Examples of inappropriate appropriate shapes for the target

Size of the target

The target should be something whose size will be approximately 80 to 100 pixels long and wide when it is snapped as an image.

Mounting the target

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

> ⚠ **CAUTION**
> Fix the target securely to the robot's gripper so that it will not get off position while robot is operating.

> **Memo**
> 1 Normally, the robot position and posture are set so that the range of robot motion becomes maximal when the robot actually operates. Therefore, mounting the target so that it can be captured by the camera when the robot is in a posture that it takes during operation makes it easier to secure the range of robot motion.
> 2 Positioning pins or other appropriate means may be used so that the target can be mounted at the same position for each measurement. This way, a robot program generated for a previous calibration operation can be used for re-calibration.

2.3.3 Camera Data Creation

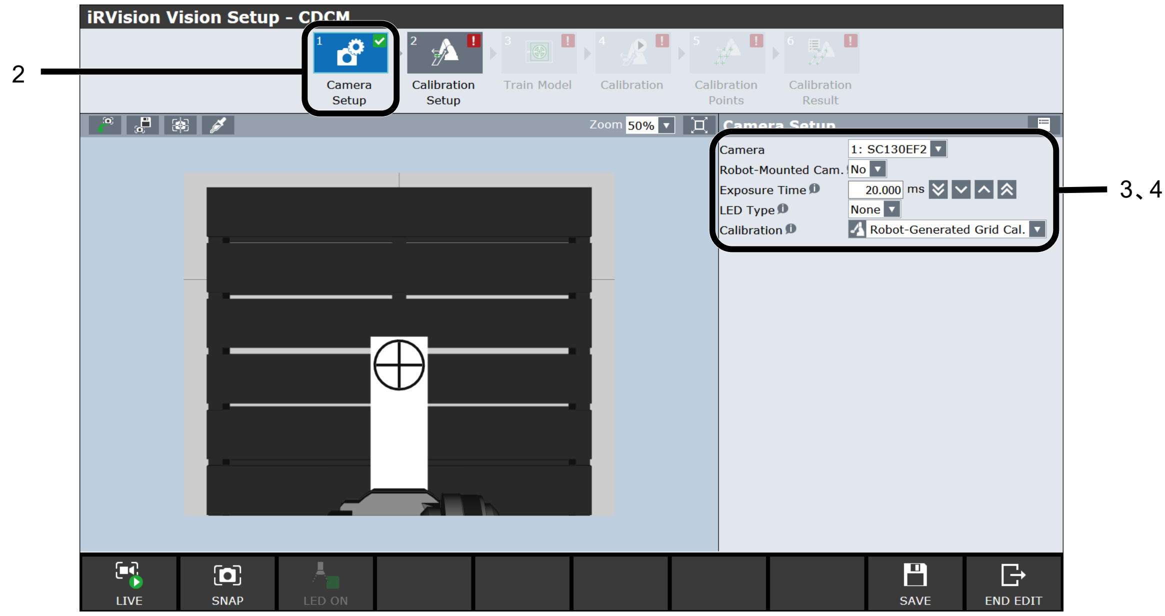
2

Create camera data for the 2D camera and set the camera type, method for camera installation, etc.
For details on the creation of vision tools including camera data, refer to the description of creating new vision data in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.3.4 Camera Setup

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

1 On the vision data list screen, click the camera data that has been created.
2 Click [1 Camera Setup] in the navigation area.
A screen like the following one will appear.



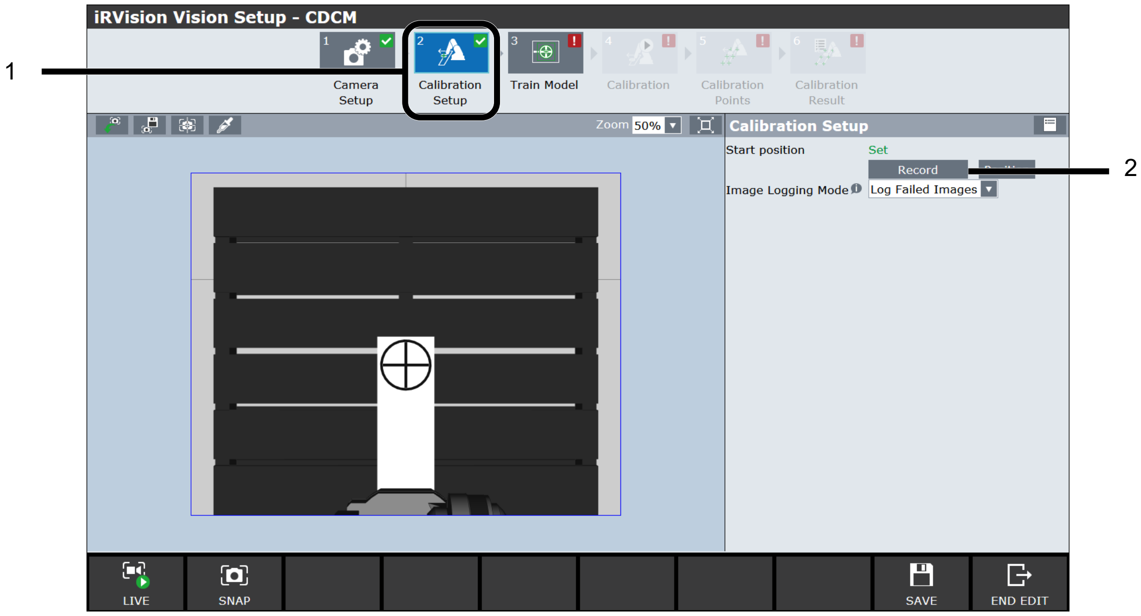
3 Set the camera to use, the method for camera installation, the exposure time, the presence/absence of LED lighting, etc.
4 Select [Robot-Generated Grid Cal.] for [Calibration].
5 Adjust the diaphragm and focus of the lens. If you click [LIVE], a live image will be displayed in the image view. Make adjustments while looking at the live image.

⚠ **CAUTION**
Adjust the diaphragm and focus of the lens before performing camera calibration. If the diaphragm and focus are readjusted, camera calibration needs to be performed again.

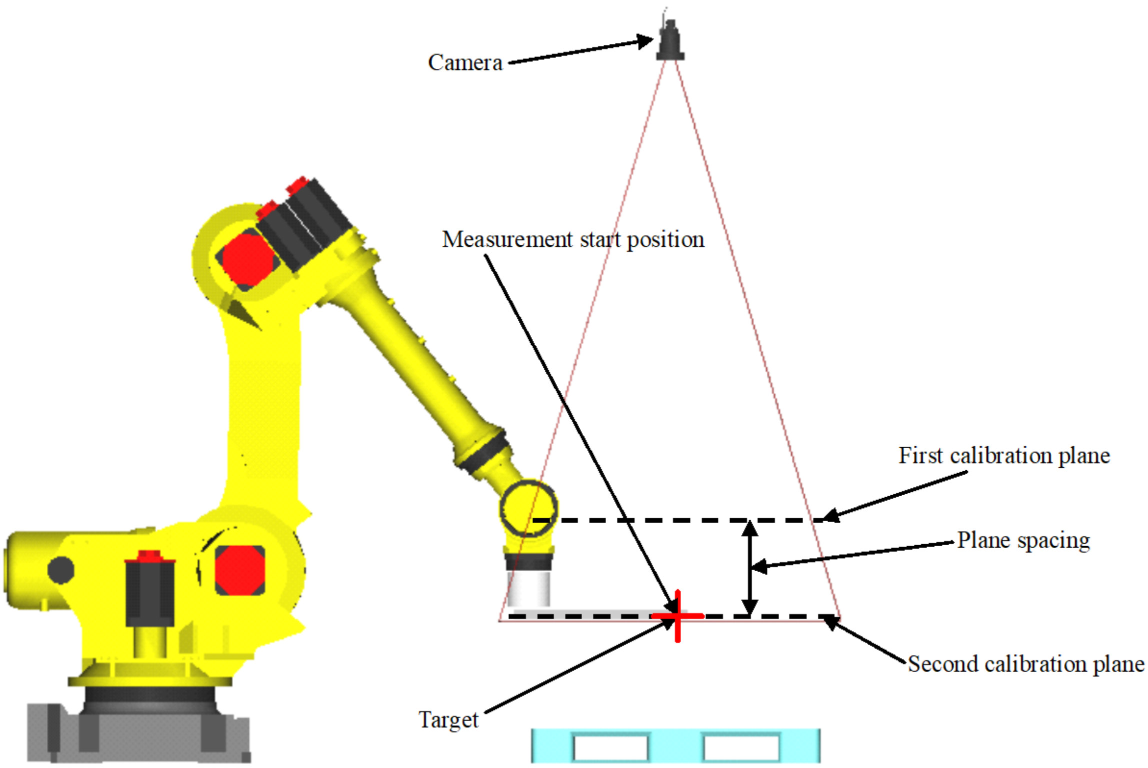
2.3.5 Calibration Setup

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

1 Select [2 Calibration Setup] in the navigation area.
The robot-generated grid calibration setup screen will appear.



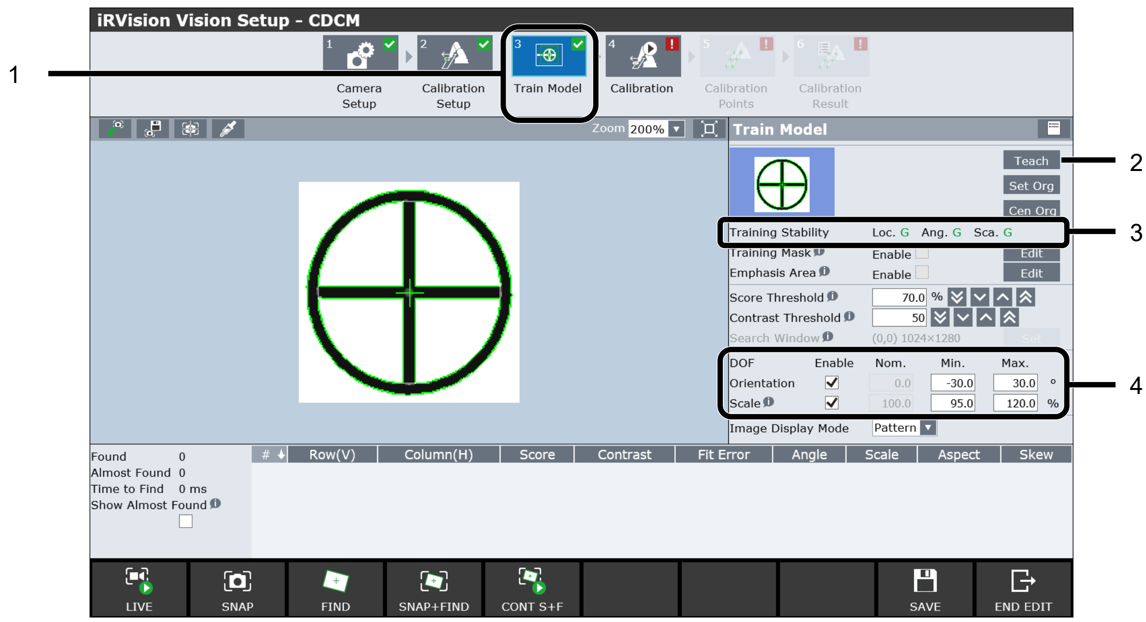
2 Click the [Record] button for [Start position]. Record the start position.
The start position should be set so that the target attached to the robot's gripper appears roughly in the center of the camera's field of view. The height of the measurement start position is the height of the 1st Plane. During camera calibration, the robot will move in parallel to the XY plane of the application frame while keeping the posture of the start position. Move the robot by jog operation to a position that will be appropriate as the start position, and click the [Record] button at that position to record the start position.



2.3.6 Teaching Model

Teach the shape of the target to use for calibration as a model pattern for the pattern match tool. Model pattern teaching is performed after moving the robot to the recorded initial position.

1 Click [3 Train Model] in the navigation area.
A screen like the following one will appear.



2 Click the [Teach] button.
A full-screen image will be displayed, and a rectangular window (reddish purple rectangle) will appear. Surround the target to teach with the rectangular window, and click [OK]. The model pattern will be taught.

> ✎ **Memo**
> Make the size of the rectangular window slightly larger than the target. During measurement, the zone of the rectangular window taught here will control the position of the robot so that it does not go out of the search window. Therefore, if the taught zone is too large compared to the target, it will not be possible to move the target to the edge of the field of view, and this may result in an inaccurate calibration result.

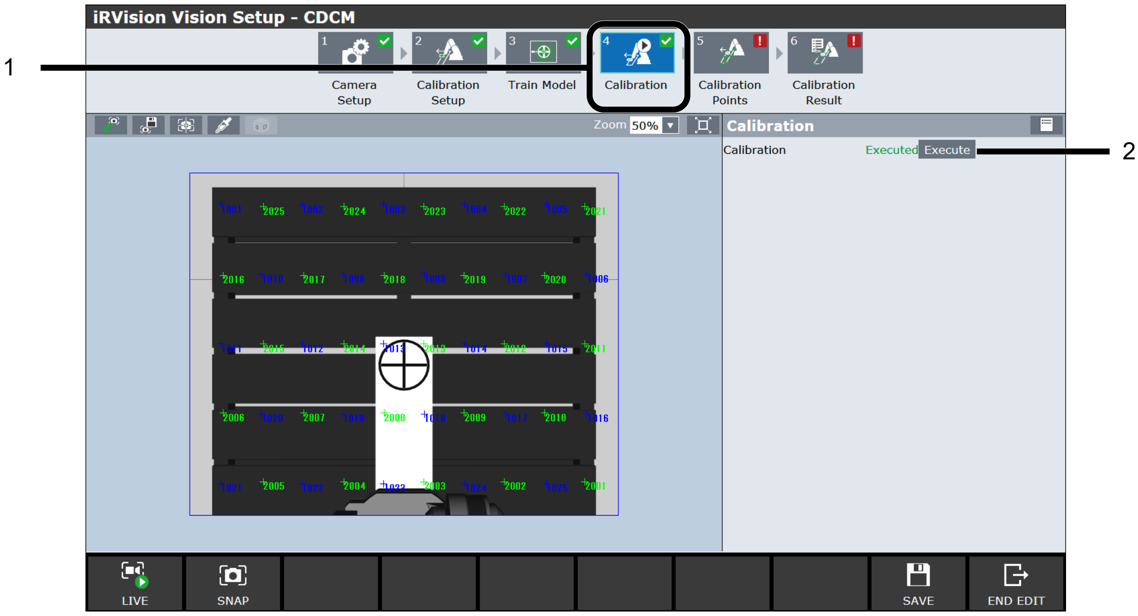
3 If a model pattern is taught, the evaluation result for the model that is taught will be displayed for [Training Stability] will be displayed.
Check that there is a ○ for Location, Angle, and Scale. Even a single × will mean calibration cannot be performed successfully, so change the shape of the target in such cases.

4 The standard values for [DOF] are ±30 for [Orientation] and 95 to 120% for [Scale]. Normally, these do not need to be changed, but adjust them as required.

2.3.7 Executing Calibration

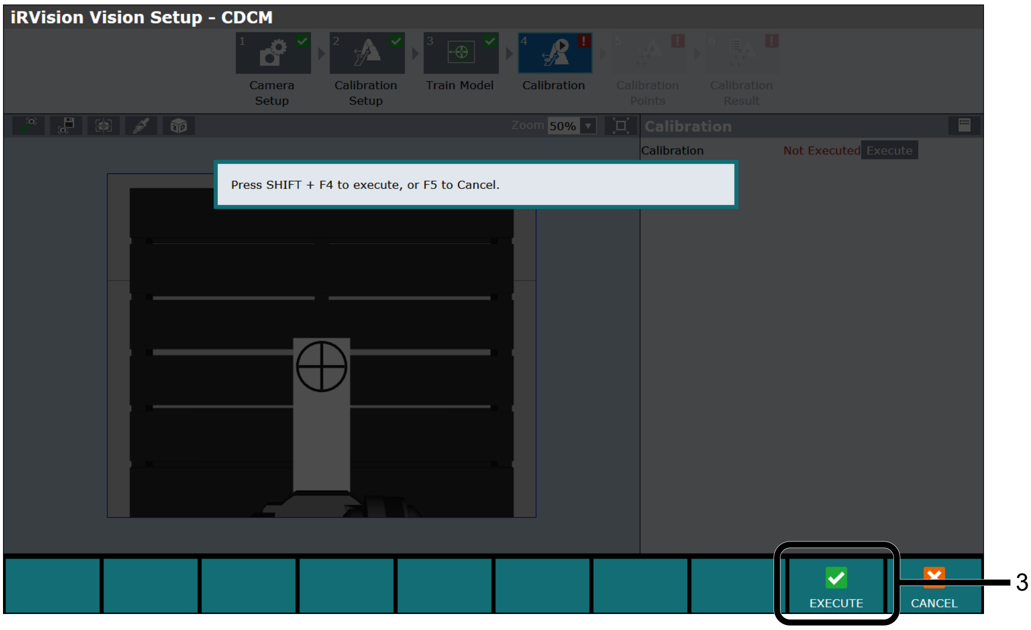
In order to execute camera calibration, select camera data on the *i*RVision utility screen.

1 Click [4 Calibration] in the navigation area.
A screen like the following one will appear.



2 Click the [Execute] button in [Calibration].

3 When the following confirmation screen appears, click the [Execute] button while holding down the [SHIFT] key on the teach pendant.

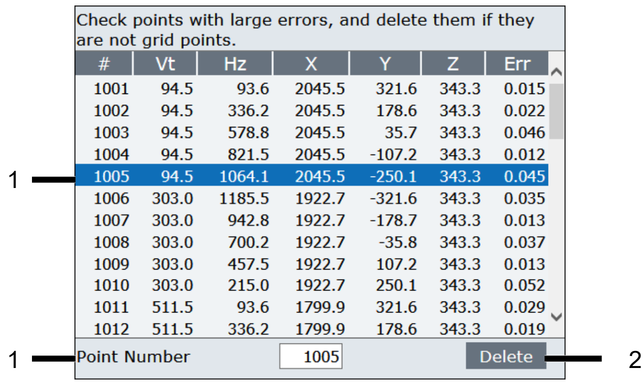


> ⚠ **CAUTION**
> 1 Releasing [SHIFT] while measurement is in progress stops the measurement. In that case, perform the measurement again. You can resume it from where it stopped.
> 2 The robot usually performs operations within an expected range according to the parameter setting. However, the robot can make a motion beyond an expected range, depending on the parameter setting. When doing the measurement, check that the related parameters are set correctly and decrease the override to 30% or less to ensure that the robot does not interfere with peripheral equipment.
> 3 If another program is paused, the robot may not be able to move. In that case, abort the program using the [FUNC] menu on the teach pendant.

2.3.8 Checking Calibration Point

Check the calibration points found in Know-how Edition Subsection 2.3.7, "Executing Calibration".

If you click [5 Calibration Points] in the navigation area, the calibration points screen will appear.


Check points with large errors, and delete them if they are not grid points.

#	Vt	Hz	X	Y	Z	Err
1001	94.5	93.6	2045.5	321.6	343.3	0.015
1002	94.5	336.2	2045.5	178.6	343.3	0.022
1003	94.5	578.8	2045.5	35.7	343.3	0.046
1004	94.5	821.5	2045.5	-107.2	343.3	0.012
1005	94.5	1064.1	2045.5	-250.1	343.3	0.045
1006	303.0	1185.5	1922.7	-321.6	343.3	0.035
1007	303.0	942.8	1922.7	-178.7	343.3	0.013
1008	303.0	700.2	1922.7	-35.8	343.3	0.037
1009	303.0	457.5	1922.7	107.2	343.3	0.013
1010	303.0	215.0	1922.7	250.1	343.3	0.052
1011	511.5	93.6	1799.9	321.6	343.3	0.029
1012	511.5	336.2	1799.9	178.6	343.3	0.019

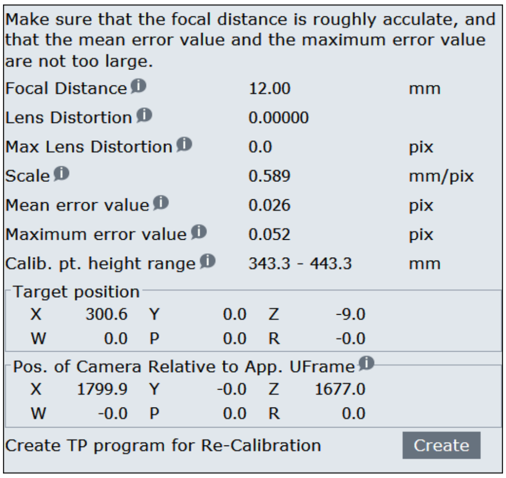
If there are any found points that have been found by mistake, delete the irrelevant found points using the following procedure.

1 Select an irrelevant found point from the found point list, or enter a found point number in the [Point Number] text box.
2 Click the [DELETE] button.
The irrelevant found point will be deleted.

2.3.9 Checking Calibration Result

Check the calculated calibration data.

If you click [6 Calibration Result] in the navigation area, the calibration result screen will appear.



Check whether the focal distance is correct, and whether the position of the fixed camera relative to the application user frame is correct.

3 SETUP OF SNAP IN MOTION

This function enables *i*RVision to snap an image without stopping robot motion, and is effective when measuring a fixed frame offset with a robot-mounted camera and/or measuring a tool offset of a part held by a robot with a fixed camera or a camera mounted on another robot. Using this function will reduce robot cycle time compared to the legacy way.

3.1 OVERVIEW OF SNAP IN MOTION

This section gives an overview of the function snap-in-motion.

3.1.1 Features

This function enables *i*RVision to snap an image without stopping robot motion, and is effective when measuring a fixed frame offset with a robot-mounted camera and/or measuring a tool offset of a part held by a robot with a fixed camera or a camera mounted on another robot. The following vision processes support this function.

- 2D Single-view Vision Process
- 2D Multi-view Vision Process
- Depalletizing Vision Process
- 3D Tri-View Vision Process

You can calibrate cameras and teach vision processes as is conventionally.
Calibration of a camera and teaching vision processes are performed in the state where it stopped. Even if it is SNAP IN MOTION, that is the same method with other applications.
Obtaining an accurate robot position at a snapping moment is a key technology to measure a fixed frame offset of part with a robot-mounted camera or a tool offset of a part held by a robot with a fixed camera or a camera mounted on another robot.
Conventionally an accurate robot position can be obtained only while a robot remains stationary. The function snap-in-motion enables measuring a fixed frame offset and a tool offset by getting an accurate robot position at a snapping moment.

This function has the following restrictions.

- The robot that holds a camera or a part should be controlled by the controller on which *i*RVision resides.
- Only one robot can move at a snapping moment.

When performing tool offset with a robot-mounted camera, two robots are used (a robot holding a camera and a robot holding a part), but the position during motion can be obtained for only one of them. Stop the other robot when snapping.

*i*RVision assumes a robot that can move at a snapping moment in the following manner:

- If [This Controller] is selected for Robot Holding the Part, the robot that held a part can move.
- If a robot other than [This Controller] is selected for Robot Holding the Part and [This Controller] is selected for Robot Holding the camera, the robot that holds a camera can move.

Above conditions are used in both cases that two robots are controlled by one controller and two controllers.

3.1.2 Using Snap in Motion

By default, the function snap-in-motion is disabled. To use this function, change the system variable $VSMO_CFG.$ENABLE to TRUE.

$VSMO_CFG.$ENABLE = TRUE
By setting this system variable to true, the function snap-in-motion itself is enabled. But, to snap an image actually without stopping robot motion, you need to modify your robot program. Refer to the Know-how Edition Subsection "3.1.4 Robot Program for Snap in Motion" about how to modify robot programs.
By enabling the function snap-in-motion, the method to obtain a robot position at the snapping moment is changed internally. Basically, you can use camera calibrations, vision processes and robot programs that you taught previously even after this function is enabled. However, potentially a quantity of errors may be observed if you continue to use camera calibrations and vision processes that you have taught before the function is enabled. In such a case, calibrate cameras and teach the reference positions again.

3.1.3 Checking Position and Speed at Snap

When the function snap-in-motion is enabled, the actual position and speed of the robot at the last snapping moment are recorded in the following system variables. Refer to these variables to determine the exposure time and so on in study for application described later.

$VSMO_VAL.$POSITION

It is the actual robot position at the snapping moment. It is in the Cartesian format. X, Y and Z are in millimeters, and W, P and R are in degrees. For a robot-mounted camera, the position of the mechanical interface relative to the [Application UFrame] is recorded. For tool offset, the position of the [Application UFrame] that you selected in the camera calibration setup page is recorded.

$VSMO_VAL.$SPEED

It is the actual robot speed at the snapping moment. X, Y and Z are in mm/sec, and W, P and R are in degrees/sec.

3.1.4 Robot Program for Snap in Motion

For snap-in-motion, you need to execute the VISION RUN_FIND instruction in a different manner from usual.

Snap after stopping

This is an example of a program for when snapping after stopping the robot, as in the conventional procedure. The operation mode in line 2 is 'FINE'. The robot's motion stops while snapping under the 'VISION RUN_FIND' command in line 3, and the motion to move to P[3] starts when snapping is complete.

```
1:  L P[1:start] 500mm/sec FINE
2:  L P[2:snap] 500mm/sec FINE
3:  VISION RUN_FIND 'A'
4:  L P[3:stop] 500mm/sec FINE
```

Snap in motion

To snap an image without stopping the robot, the VISION RUN_FIND instruction should be executed by using the TIME BEFORE instruction. In the robot program below, 'CNT100' is specified for P[2] in the second line, and the subprogram FIND.TP is called at the moment that the robot passes through P[2] by using the TIME BEFORE instruction.

```
1:  L P[1:start] 500mm/sec FINE
2:  L P[2:snap] 500mm/sec CNT100 TB 0.00sec,CALL 'FIND'
3:  L P[3:stop] 500mm/sec FINE
```

FIND.TP that is called by the TIME_BEFORE instruction is as below. The VISION RUN_FIND function is executed in this subprogram.

```
1:    VISION RUN_FIND 'A'
```

You can tweak the start time of the TIME BEFORE instruction, or you can use the TIME AFTER instruction or the DISTANCE BEFORE instruction instead of the TIME BEFORE instruction. For these instructions, refer to "OPERATOR'S MANUAL (Basic Operation) B-83284EN".

If positions P[1] ~ P[3] in the above program are not on a line, the robot moves inside of the original path and does not pass through P[2] because of CNT100. In such a case, modify P[2] so that the robot actually passes through the expected snap position.

3.1.5 Notes

Vibration of robot arm while robot moving is not considered. The bigger the vibration is, the larger the error is.

3.2 STUDY FOR APPLICATION

This section describes issues to consider when the function snap-in-motion is used.

3.2.1 Light and Exposure Time

If the function snap-in-motion is used, the camera or the target is moving during the exposure, so the snapped image will be blurred to that extent. Because this blur can cause detection error, the exposure time should be set a smaller value than usual to mitigate the blur.

Assuming that the robot moves in the direction at a right angle to the optical axis of the camera, the amount of blur is calculated by the expression $V \times T \times N \div S$ in pixels, where V is the velocity at the snapping moment in mm/sec, T is the exposure time in sec, S is the size of the camera field of view in millimeters and N is the number of effective pixels of the camera.

$$(\text{Pixels}) = V \times T \times N \div S$$

Determine the exposure time so that this amount of blur is smaller than one pixel and prepare a good light source to get a fully bright image with the selected exposure time.

3.2.2 Image Processing Time and Motion Time

When using the function to capture without stopping, it is necessary to pay attention to the relationship between the time required for image processing and the time required for robot operation.

GET_OFFSET

The following program calls the subprogram FIND.TP, which include the VISION RUN_FIND instruction, at the moment that the robot passes through P[2] in the second line, and tries to get the resulting vision offset in the line 4. If P[2] and P[3] were too close and the robot reached P[3] in a short time, the robot would wait for the completion of vision detection in the fourth line, resulting the robot stopping. To avoid such a thing, consider a good layout of the camera so that the image processing finishes while the robot is moving from P[2] to P[3].

```
1:  L P[1:start] 500mm/sec CNT100
2:  L P[2:snap] 500mm/sec CNT100 TB 0.00sec,CALL FIND
3:  L P[3:stop] 500mm/sec CNT100
4:  VISION GET_OFFSET 'A' VR[1] JMP,LBL[1]
5:  L P[4:approach] 500mm/sec FINE VOFFSET,VR[1]
```

Continuous RUN_FINDs

In *i*RVision, vision detection that has been executed first has to be completed before the next vision detection can be started. Therefore, if you start up vision detection consecutively in a short interval, the vision detection that comes after will be kept waiting, and as a result, it will not be able to snap an image at the expected position.
For example, in the following program, if the time to move from P[2] to P[3] is shorter than the time for the image processing for FIND1.TP, snapping an image for FIND2.TP will be delayed.

```
1:  L P[1:start] 500mm/sec CNT100
2:  L P[2:snap1] 500mm/sec CNT100 TB 0.00sec,CALL FIND1
3:  L P[3:snap2] 500mm/sec CNT100 TB 0.00sec,CALL FIND2
4:  L P[4:stop] 500mm/sec CNT100
```

Time a vision process takes depends on the shape of the trained model pattern, the detection parameters, the condition of the snapped image, and the load of the controller that performs the vision process. Check your vision process time by actually executing the vision process.
In addition, if the vision process executed previously is configured to log images, the next vision process can be kept waiting until the previous vision process completes image logging and snapping an image of the next vision process can be delayed. In such a case, configure the previous vision process not to log images. The delay of snapping an image can be shortened slightly if the ‘Enable Logging’ is checked off in the *i*RVision configuration setup page.

3.2.3 Shift of Snap Position

Depending on the condition of the controller, timing of snap may be fluctuated slightly. The shift of the snap timing is basically no problem, because *i*RVision can get an accurate robot position at snapping. But if the size of the camera field of view is adjusted so that an image is filled with a part, the shift of the snap timing lead the part being out of the camera field of view and that causes detection failure. Set the size of the camera field of view to have enough margins to accept a quantity of the shift of the snap timing. The size of margin depends on the speed of the robot at snapping. The faster the robot is moving, the bigger the shift of the snapping position is.
Moreover, after turning on a controller, in the first vision detection, detection time may take a few seconds longer. About the detection time of the second times, it becomes the normal detection speed. At the detection of first time, when the shift of the snap timing occurs, perform the detection of first time at somewhere else before the performing snap in motion.

Memo
Vision Processes are saved in the FROM or memory card. In addition, If Vision Process is performed, it will remain in the cache in DRAM. Since access to the file in cache is quick, the vision detection of second time becomes early rather than the first time. Since Vision processes in the cache are deleted at the turning off a control, the detection speed at first time after turning on a control may become long. In addition, there is a limitation in the cache domain of DRAM. So other Vision Processes are run, old Vision Processes in the cache will be deleted from cache. In the system that runs many kinds of Vision Processes in one cycle, some of the executed Vision Processes may not remain in cache. The capacity of cache is 2 MB as an initial value.

3.3 SAMPLE APPLICATIONS

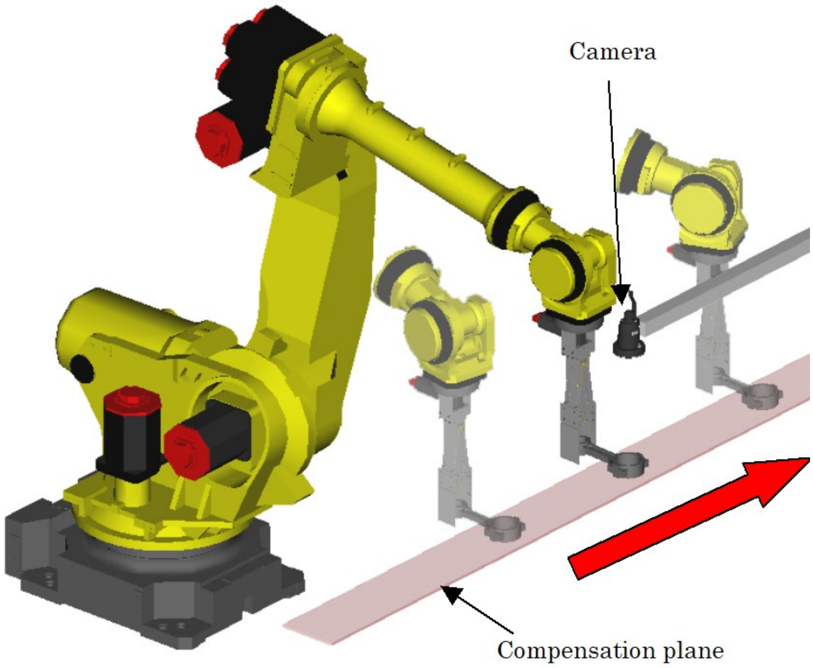
This section demonstrates three sample applications using the function snap-in-motion.

- Tool offset with a fixed-mounted camera (2D Single-view Vision Process)
- Tool offset with a fixed-mounted camera (2D Multi-view Vision Process)
- Fixed frame offset with a robot-mounted camera (3D Tri-view Vision Process)

In either application, generally the setup procedure and items to consider are the same as those of each application without the function snap-in-motion. The descriptions about the area of overlap with those in each vision processes are left out.

3.3.1 Tool Offset with a Fixed Camera (2D single-view vision process)

Tool offset with a fixed camera (2-D Single-view vision process) measures the amount of tool offset by snapping the workpiece that the robot is gripping, using a fixed camera. Using the measured tool offset, the robot positions are compensated to put the part in a correct position. The tool offset is usually measured with stopping the robot. Using the function snap-in-motion, the vision detection can be executed while the robot is transporting a part without stopping robot motion.
The subsection “1.4.4 Robot Program Creation and Teaching” in the setup procedure described in the section “1.4 SETUP FOR TOOL OFFSET WITH FIXED CAMERA” is different from those using the function snap-in-motion. ‘Robot Program Creation and Teaching’ is explained below.
The figure below is an example of layout in the case of tool offset using 2D Single-view Vision Process with a fixed-mounted camera.



Tool offset with a fixed camera (2-D Single-View Vision Process)

3.3.1.1 Robot program creation and teaching

This subsection demonstrates robot programs for tool offset in motion. Based on sample robot programs below, create appropriate robot programs for your application.

The following two programs are created.

- Main robot program (MAIN.TP)
- Robot program to detect a target (FIND.TP)

MAIN.TP

This is the main program. In this program, the robot moves from the start position P[1] to the stop position P[3] through the snap position P[2], and call the subprogram FIND.TP at the moment that the robot passes through the snap position. After that, the VISION GET_OFFSET instruction is called to get the resulting vision offset. The robot positions P[4] and P[5] are compensated with the vision offset so that the part is put at the correct location.

```
UFRAME_NUM=1
UTOOL_NUM=1

L P[1:start] 500mm/sec CNT100
L P[2:snap] 500mm/sec CNT100 TB 0.00sec,CALL FIND
L P[3:stop] 500mm/sec CNT100
VISION GET_OFFSET 'A'  VR[1] JMP LBL[99]
L P[4:approach] 500mm/sec FINE VOFFSET,VR[1]
L P[5:set] 100mm/sec FINE VOFFSET,VR[1]
L P[4:approach] 100mm/sec FINE VOFFSET,VR[1]
END
LBL[99]
UALM[1]
```

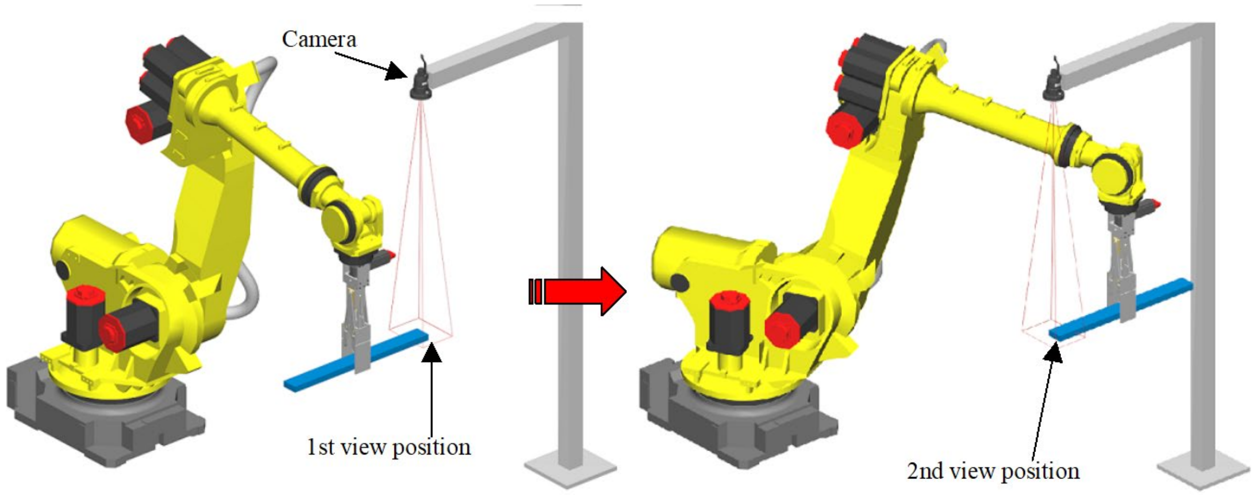
FIND.TP

This is a program called by the TIME BEFORE instruction. This program executes the vision process “A” using the VISION RUN_FIND instruction.

```
  1:  VISION RUN_FIND 'A'
```


3.3.2 Tool Offset with a Fixed Camera (2D multi-view vision process)

Tool offset with a fixed camera (2-D Multi-View Vision Process) measures the amount of tool offset of a workpiece by snapping multiple features on a large workpiece that the robot is gripping, using a fixed camera. Using the measured tool offset, robot positions are compensated to put the part at a correct position. The tool offset is usually measured with stopping the robot. Using the function snap-in-motion, the vision detection can be executed while the robot is transporting a part without stopping robot motion.
The subsection “2.4.4 Robot Program Creation and Teaching” in the setup procedure described in the section “2.4 SETUP FOR TOOL OFFSET WITH FIXED CAMERA” is different from those using the function snap-in-motion. ‘Robot Program Creation and Teaching’ is explained below.
The figure below is an example of layout in the case of tool offset using 2D Multi-view vision process with a fixed-mounted camera.



Tool offset with a fixed camera (2-D Multi-View Vision Process)

3.3.2.1 Robot program creation and teaching

This subsection demonstrates robot programs for tool offset in motion. Based on sample robot programs below, create appropriate robot programs for you application.

Following two programs are created.

- Main robot program (MAIN.TP)
- Robot program to detect a target (FIND.TP)

MAIN.TP

This is the main program. In this program, the robot moves from the start position P[1] to the stop position P[4] through the two snap positions P[2] and P[3], and calls the subprogram FIND.TP with a camera view number as an argument at the moment that the robot passes through the snap positions. In order to confirm that the vision processes are completed in every camera view, it waits until R[1] becomes 2. After that, the VISION GET_OFFSET instruction is called to get the resulting vision offset. The WAIT instruction secures that the VISION GET_OFFSET instruction is executed after the VISION RUN_FIND completion. The robot positions P[5] and P[6] are compensated with the vision offset so that the part is put at the correct location.

```
UFRAME_NUM=1
UTOOL_NUM=1

R[1]=0
L P[1:start] 500mm/sec CNT100
L P[2:snap1] 500mm/sec CNT100 TB 0.00sec,CALL FIND(1)
L P[3:snap2] 500mm/sec CNT100 TB 0.00sec,CALL FIND(2)
L P[4:stop] 500mm/sec CNT100
WAIT R[1]>=2
VISION GET_OFFSET 'A' VR[1] JMP LBL[99]
L P[5:approach] 500mm/sec FINE VOFFSET,VR[1]
L P[6:set] 100mm/sec FINE VOFFSET,VR[1]
L P[5:approach] 500mm/sec FINE VOFFSET,VR[1]
END
LBL[99]
UALM[1]
```

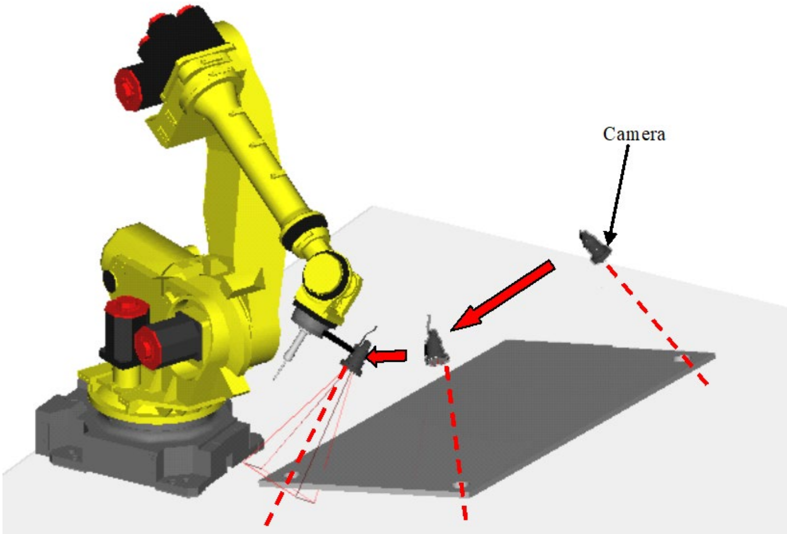
FIND.TP

This is a program called by the TIME BEFORE instruction. This program executes detection of the camera view specified by the argument using the VISION RUN_FIND instruction. And R[1] is incremented after the image acquisition completes.

```
VISION RUN_FIND 'A' CAMERA_VIEW[AR[1]]
R[1]=R[1]+1
```

3.3.3 Fixed Frame Offset with a Robot Mounted Camera (3D Tri-view vision process)

In a fixed frame offset application with a robot-mounted camera of 3D Tri-view Vision Process, three features on a part are detected by the robot mounted-camera and the 3D position of the part is measured. Using the measured position, robot positions are compensated so that the tool of the robot can reach the part. The fixed frame offset is usually measured with stopping the robot.
Using the function snap-in-motion, the measurements can be executed continuously without stopping the robot holding the camera at each snap position.
The subsection “4.3.3 Robot Program Creation and Teaching” in the setup procedure described in the section “4.2 SETUP FOR FIXED FRAME OFFSET WITH FIXED CAMERA” is different from those using the function snap-in-motion. “ROBOT PROGRAM CREATION AND TEACHING” is explained below.
The figure below is an example of layout in the case of fixed frame offset using 3D Tri-view vision process with a robot-mounted camera.



Tool offset with a fixed camera (3-D Tri-View Vision Process)

3.3.3.1 Robot program creation and teaching

Here, examples of robot programs for performing snap-in-motion and fixed frame offset are described. Change the programs to suit each system, referring the robot programs described here.

The following two robot programs will be created.

- Main robot program (MAIN.TP)
- Detection robot program (FIND.TP)

MAIN.TP

This is a main program. In this program, the robot moves from the start position P[1] to the stop position P[5] through the three snap positions P[2] ~ P[4], and calls the subprogram FIND.TP with a camera view number as an argument at the moment that the robot passes through each snap position. To confirm that the vision processes are completed in every camera view, it waits until R[1] become 3. After that, the VISION GET_OFFSET instruction is called to get the vision offset. The WAIT instruction can prevent that the VISION GET_OFFSET instruction executes previously rather than VISION RUN_FIND is completed. The robot positions P[6] and P[7] are compensated with the vision offset so that the robot holds the part.

```
UFRAME_NUM=1
UTOOL_NUM=1

R[1]=0
L P[1:start] 500mm/sec CNT100
L P[2:snap1] 500mm/sec CNT100 TB 0.00sec,CALL FIND(1)
L P[3:snap2] 500mm/sec CNT100 TB 0.00sec,CALL FIND(2)
L P[4:snap3] 500mm/sec CNT100 TB 0.00sec,CALL FIND(3)
L P[5:stop] 500mm/sec CNT100
WAIT R[1]>=3
VISION GET_OFFSET 'A' VR[1] JMP LBL[99]
L P[6:approach] 500mm/sec FINE VOFFSET,VR[1]
L P[7:hold] 100mm/sec FINE VOFFSET,VR[1]
L P[6:approach] 500mm/sec FINE VOFFSET,VR[1]
END
LBL[99]
UALM[1]
```

FIND.TP

This is a program called by the TIME BEFORE instruction. This program executes detection in the camera view specified by the argument using the VISION RUN_FIND instruction. And R[1] is incremented after the image acquisition completes.

```
VISION RUN_FIND 'A' CAMERA_VIEW[AR[1]]
R[1]=R[1]+1
```

4 FAQS FOR TROUBLESHOOTING

4.1 METHOD FOR ADJUSTMENTS AFTER CAMERA REPLACEMENT

I don't know how to make adjustments after camera replacement

Measures: If the camera breaks for some reason, replace it and readjust using the following procedure.

1 Cut off the power supply to the robot controller. By cutting off the power supply to the robot controller, the power supply to the camera will be cut off.
2 Remove the camera. When doing this, be careful not to apply any pressure to the diaphragm and the focus ring of the lens.
3 Remove the lens from the camera.
4 Attach the lens that was removed in step 3 to the new camera.
5 Install the camera and fix it in place.
6 Perform camera calibration.

The work is now complete.
Before removing a camera that is in operation, double-check that the diaphragm of the lens and the focus ring are fixed securely in place and will not move.
Furthermore, the lens is reusable. If you replace the lens without moving the focus or the lens ring, readjustment of the locator tools will be unnecessary, which will make the work easier.

4.2 VISION DATA RECOVERY

I don't know how to recover vision data

Measures: Recover vision data using the following procedure.

1 Prepare a memory card on which you have made a backup in accordance with the procedure in Introduction Edition Section 2.7, "MEMORY CARD PREPARATION".
2 The extension for vision data files is VD. If you load all the *.VD files, the vision data will be recovered.

Be careful with the version ID if the robot controller to copy from is different from the robot controller to copy to. The version ID of the robot controller to copy to needs to be the same or higher than that of the robot controller to be copied from.

4.3 DETECTION PROBLEMS

The expected workpiece is not being detected (not found)

Measures: Please check the following.

- Set it so that logged images are saved, and save the not-found image. Adjust the locator tool parameters using several images for which detection failed. If saving logged images, refer to the description of Vision Config in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN". After finishing adjustment, change the settings so that images will not be saved. The detection time may be longer if found images are being saved.
- Adjust the parameters while referring to the logged images. By placing a check by [Show Almost Found], you will be able to tell which parameter settings are causing the not-founds.
- If part of the image is causing halation so that the workpiece is difficult to see, the effect may be reduced to some extent by using the multi exposure function. However the detection time may be longer if the multi exposure function is used. If it is necessary to reduce the detection time, do not using multi exposure to prevent halation, but rather, change the position of the lighting, etc.
- If the contrast between the workpiece and the background is low, the workpiece's features may not be seen clearly. When detecting the outline of a workpiece with a pattern match tool, if the workpiece is light-colored, the workpiece will be seen clearly if you set the background to a dark color.
- When applying the [Depalletizing Vision Process], if detection becomes impossible when the number of layers is changed, check whether the [Scale] for the DOF has been set to something valid.

A different workpiece from the expected one is being detected (false detection)

Measures: Please check the following.

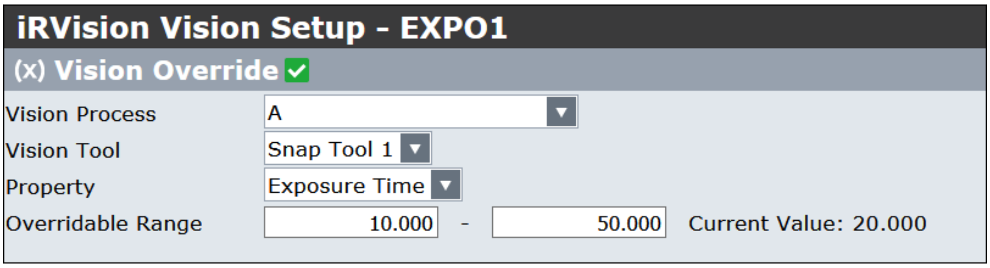
- Set it so that logged images are saved, and save the false-detection image. Adjust the locator tool parameters using several images for which detection failed. If saving logged images, refer to the description of Vision Config in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN". After finishing adjustment, change the settings so that images will not be saved. The detection time may be longer if found images are being saved.
- Adjust the parameters while referring to the logged images. You can make adjustments using methods like the following:
  - Reduce the search area to until it is the smallest one that is necessary.
  - Set the DOF for [Orientation], [Scale], and [Aspect] to the smallest that are necessary.
  - Reduce [Elasticity].
  - Reduce the setting value for [Area Overlap].
  - Set the [Emphasis Area].
- If the workpiece has only a few model features, matching will be likely to occur at various places within the field of view, which makes it easy for false detection to occur. By increasing the number of model features, you will be able to perform detection that is less likely to be affected by noise. If the number of model features is increased, the detection score may decrease compared to when the model had only few features. In such cases, set the score to something low. Even if the score is set to something low, it will still be effective as a false-detection prevention measure if the number of model features is increased.
- Enabling [Ignore Polarity] in the setting items for things like pattern match will make it easy for false detection to occur. It should basically be set to disabled.

I don't know how to redetect

Measures: If detection has failed owing to a not-found, etc., the detection can be retried using vision override while changing the detection parameters. For details on vision override, refer to the description of Vision Override in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

An example of retry while changing the exposure time in a 2-D single-view vision process is shown below.

The following figure is the setup screen for vision override. Suppose that the vision process name is 'A', and the vision override name is 'EXPO1'.



The following is a sample program. Vision detection is performed in line 15. As an example, the exposure time here is set to 20 ms. If the vision detection has failed, a vision variable setting instruction is called in line 20, and the exposure time is changed to the value stored in register [5] (for example, 25 ms). If detection is performed again in this state by executing vision process 'A' in line 15, an image will be snapped with an exposure time of 25 ms.

```
12:   R[20:retry]=0
13:   R[15:notfound]=0
14:   LBL[100]
15:   VISION RUN_FIND 'A'
16:   VISION GET_OFFSET 'A' VR[1] JMP LBL[10]
17:   JMP LBL[20]
18:   LBL[10]
19:   IF R[20:retry]=1,JMP LBL[900]
20:   VISION OVERRIDE 'EXPO1' R[5]
21:   R[20:retry]=1
22:   JMP LBL[100]
23:
24:   LBL[20]
;
34:   LBL[900]
35:   R[15:notfound]=1
;
```

Vision override does not overwrite the content of the vision process itself. The values that are overwritten by override are only enabled for the vision detection instruction immediately after the vision variable setting instruction is executed. Once the vision detection instruction is executed, all values set by the vision variable setting instruction (and all vision variables related to vision processes other than the one that executed detection) will be cleared.

The lighting environment is not stable

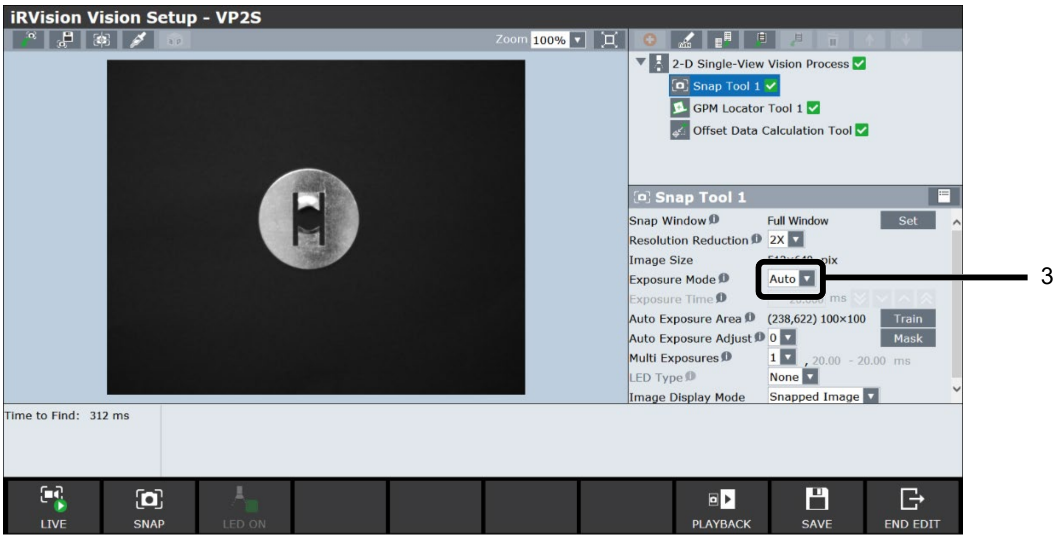
Cause: In an environment where the intensity in the field of view is not constant between day and night, detection may not be stable.

Measure 1: By using the auto exposure function, detection that is resistant to intensity changes can be performed. Auto exposure is a function that automatically selects the exposure time in response to the ambient environment so that the intensity of a snapped image will be the same as that of a reference image. This is done by registering in advance an image with an intensity to use as the reference.

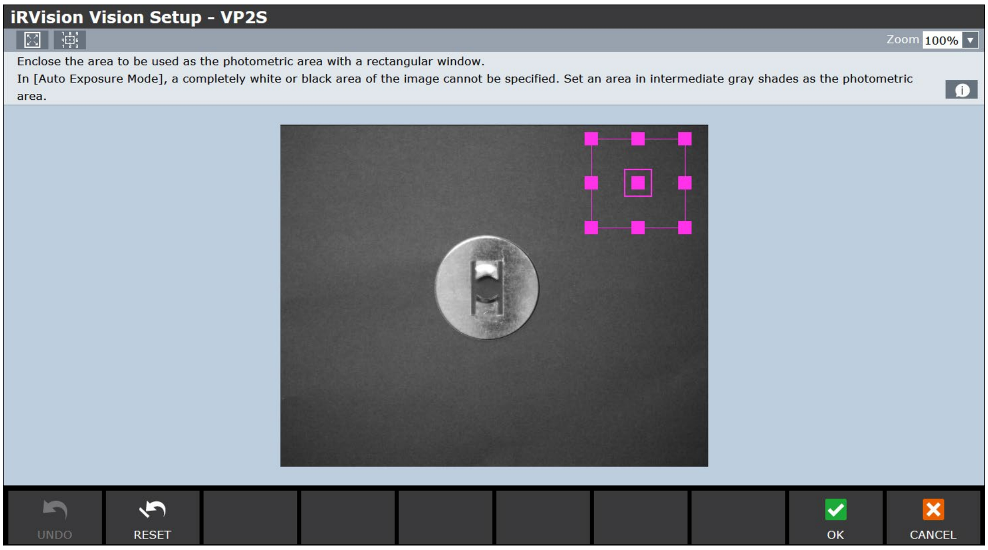
How to specify the auto exposure area

Specify the auto exposure area. The image that was being displayed when you set the auto exposure area will be the reference image for auto exposure. Set up the auto exposure area using the following procedure.

1 From the [Exposure Mode] drop-down box, select [No].
2 Adjust the exposure time so that the image has an appropriate intensity.
3 In the [Exposure Mode] drop-down box, change the selection to [Auto]. Click [OK] on the displayed pop-up that asks for the auto exposure area to be taught.



4 Set the auto exposure area.
- If the auto exposure area has not been taught yet, a window for teaching the auto exposure area will appear, so set the auto exposure area using the window.
- If the auto exposure area has already been taught, click the [Train] button for [Auto Exposure Area] to change the position and size of the auto exposure area.



5 If there is a section you want to ignore in the auto exposure area, click the [Mask] button and mask the section you want to ignore.

Memo

1 A section in the image that is completely white or completely black cannot be specified as the auto exposure area. Set a section that has intermediate colors to be the auto exposure area.
2 A section in which the image changes significantly is not suitable as an auto exposure area. For example, in a place where there is sometimes a workpiece and sometimes not, stable photometry cannot be performed, as the intensity of its appearance will change significantly depending on the presence or absence of a workpiece.

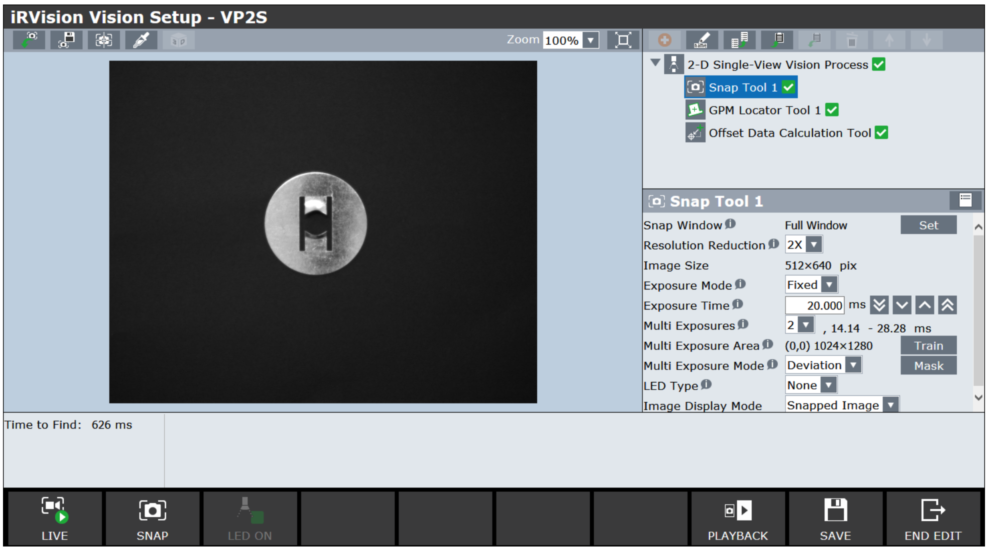
How to make fine adjustments for auto exposure

Fine adjustments can be made in auto exposure so that an image will be snapped that has an intensity that is a little brighter or darker than that of the set reference image. A value from -5 to +5 can be selected. The larger the value gets in the + direction, the brighter the image will be, and the larger the value gets in the - direction, the darker the image will be.

⚠ CAUTION

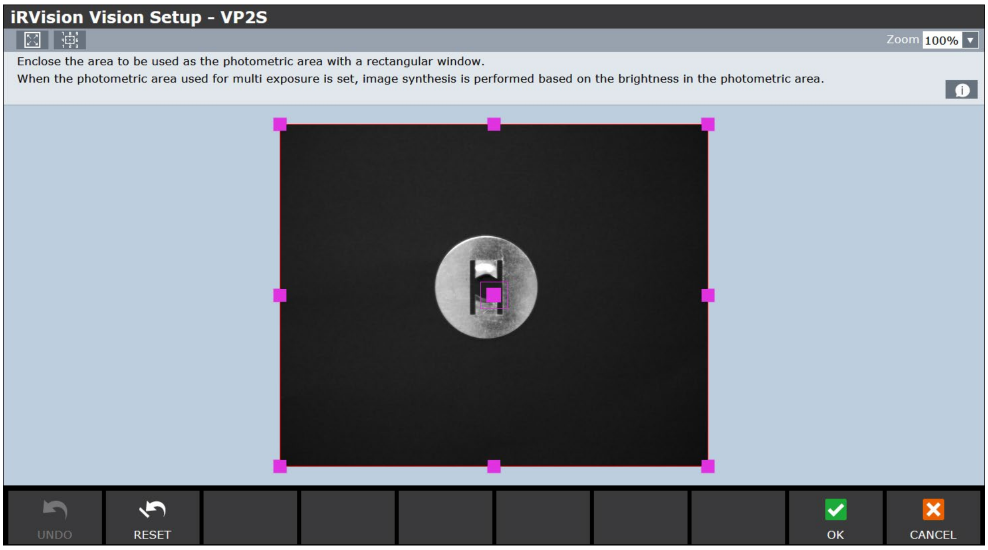
As auto exposure and multi exposures create a single image by snapping multiple images at a time, the snap-in-motion function cannot be used.

Measure 2: Multi exposure snaps multiple images using different exposure times, and creates an image with a wide dynamic range by combining them. The same as with auto exposure, detection that is resistant to intensity changes can be performed. Specify the number of images to snap. A number between 1 and 6 can be set. The more images are taken, the wider the dynamic range will be, but the time it takes to snap the images will also be longer. Also the outlines in the image may be blurred overall.



How to specify the multi exposure area

Specify the exposure area used for multi exposure. Images are combined on the basis of the intensity inside the multi exposure area. The whole of the screen is set by default, and normally, this does not need to be changed. To set the multi exposure area, click the [Train] button and set the window. If there is a section you want to ignore in the auto exposure area, click the [Mask] button and mask the section you want to ignore.



Multi Exposure Mode

Select the method for combining the images in multi exposure.

- Deviation
  For the images in a multi exposure area, the deviation of the luminance is calculated, and the images are combined in such a way that only a few pixels that cause halation will remain. This is the default setting.

- Maximum
  Images are combined by suppressing the maximum luminance so that the images in the multi exposure area do not cause halation. If there is even a part of the multi exposure area where halation is occurring at even a single point in, all other parts will become relatively darker.
- Average
  A combination method that simply calculates the average intensity of each image. Although it is the method for which the dynamic range is widest, the image will be darker overall.

> ⚠ **CAUTION**
> As auto exposure and multi exposures create a single image by snapping multiple images at a time, the snap-in-motion function cannot be used.

Detection is taking a long time

Cause 1: A loop using an upward jump label that includes an operation statement with a movement distance that is 0 has been programmed in.
Depending on how the TP program is created, it may not be possible to process vision data because almost all of the CPU's capacity will be used for program execution. Specifically, this applies in cases where a program with a loop that uses an upward jump has been created, and in that loop, there is an operation statement for which the movement distance is zero. In such cases, if there is an 'operation statement for moving to a waiting position', then the movement distance of the operation statement will be zero starting from the second run of the loop.

Measures: You can check whether the TP program has the above logic or not by changing the value of the system variable $PG_CFG.$JMPWAIT_UPR to '16' (the default is '-16').

> ⚠ **CAUTION**
> Changing the above system variable will put the system into the same state as if a WAIT of 16 ms had been entered in all the upward jumps. If there is a problem with application as a result of this change, analyze the TP program to identify the loop that is causing the problem, and enter a WAIT instruction in that loop (set the system variable back to the default).

Cause 2: The execution history is being saved.

Measures: If the execution history is being saved using a USB memory, it may take a long time to perform vision detection.

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REVISION RECORD

Edition	Date	Contents
03	May, 2021	• Applied to series 7DF5/06 (V9.40P/06) • Applied to R-30*i*B Mini Plus controller
02	Sep., 2020	• Applied to series 7DF3/06 (V9.30P/06) • Applied to R-30*i*B Mate Plus/R-30*i*B Compact Plus controller
01	Oct., 2012	

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