FANUC Robot series

R-30iB Plus/R-30iB Mate Plus/R-30iB Compact Plus CONTROLLER

iRVision Bin Picking Application OPERATOR'S MANUAL

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.

- No part of this manual may be reproduced in any form.
- The appearance and specifications of this product are subject to change without notice.

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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 must be read before using the robot.

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 DEFINITION OF USER

The 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 safety fence

Maintenance technician:

- Operates the robot
- Teaches the robot inside the safety fence
- Performs maintenance (repair, adjustment, replacement)
- Operator is not allowed to work in the safety fence.
- Programmer/Teaching operator and maintenance technician are allowed to work in the safety fence. Works carried out in the safety fence include transportation, installation, teaching, adjustment, and maintenance.
- To work inside the safety fence, the person must be trained on proper robot operation.

Table 1 (a) lists the work outside the safety fence. In this table, the symbol "O" means the work allowed to be carried out by the worker.

Table 1 (a) List of work outside the fence

	Operator	Programmer or Teaching operator	Maintenance technician
Turn power ON/OFF to Robot controller	0	0	0
Select operating mode (AUTO/T1/T2)		0	0
Select remote/local mode		0	0
Select robot program with teach pendant		0	0
Select robot program with external device		0	0
Start robot program with operator's panel	0	0	0
Start robot program with teach pendant		0	0
Reset alarm with operator's panel		0	0
Reset alarm with teach pendant		0	0
Set data on teach pendant		0	0
Teaching with teach pendant		0	0
Emergency stop with operator's panel	0	0	0
Emergency stop with teach pendant	0	0	0
Operator's panel maintenance			0
Teach pendant maintenance			0

In the robot operating, 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.

• Check this manual thoroughly, and keep it handy for the future reference.

SA	FETY P	RECAUTIONS	s-1
In	troduct	ion	
1	PRFF4	ACE	3
•		OVERVIEW OF THE MANUAL	
		RELATED MANUALS	
2		CKING	
		SUPPORTED FUNCTIONS	
		KEY CONCEPT	
		PARTS LIST MANAGER	
	-	2.3.1 Login to Parts List Manager	
		INTERFERENCE AVOIDANCE	
		2.4.1 Login to Interference Avoidance Setup	
3	CONFI	GURATION AND FEATURES	12
	3.1	BIN PICKING SYSTEM WITH 3D AREA SENSOR	12
	3.2	FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR	14
1		CKING SYSTEM WITH 3D AREA SENSOR INSTALLATION AND CONNECTION OF 3D AREA SENSOR	
		USER FRAME SETUP	
		SETTING UP 3D AREA SENSOR DATA	1 ()
		1.3.1 Selecting 3D Area Sensor Data	18
		1.3.1 Selecting 3D Area Sensor Data1.3.2 3D Area Sensor Configuration	1 8
		1.3.2 3D Area Sensor Configuration	18 19 20
		1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model	18 19 20 21
		1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration	
		1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration Checking Calibration Point	
		1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result	
		1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup	
	1.4	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data 1.5.2 Setting Interference Setup (Robot) Data	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data 1.5.2 Setting Interference Setup (Robot) Data 1.5.3 Setting Interference Setup (Condition) Data	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data 1.5.2 Setting Interference Setup (Robot) Data 1.5.3 Setting Interference Setup (Condition) Data SEARCH VISION PROCESS SETUP	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data 1.5.2 Setting Interference Setup (Robot) Data 1.5.3 Setting Interference Setup (Condition) Data SEARCH VISION PROCESS SETUP 1.6.1 Vision Process Setup	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data 1.5.2 Setting Interference Setup (Robot) Data 1.5.3 Setting Interference Setup (Condition) Data SEARCH VISION PROCESS SETUP 1.6.1 Vision Process Setup	
	1.4 1.5	1.3.2 3D Area Sensor Configuration 1.3.3 Calibration Setup 1.3.4 Train Model 1.3.5 Calibration 1.3.6 Checking Calibration Point 1.3.7 Checking Calibration Result 1.3.8 3D Area Sensor Setup TOOL FRAME SETUP SETUP OF INTERFERENCE AVOIDANCE DATA 1.5.1 Setting Interference Setup (System) Data 1.5.2 Setting Interference Setup (Robot) Data 1.5.3 Setting Interference Setup (Condition) Data SEARCH VISION PROCESS SETUP 1.6.1 Vision Process Setup 1.6.2 Command Tool Teaching 1.6.2.1 Teaching the 3D data preprocess tool	

		1.7.2 Setting SEARCH VP List	
		1.7.4 Settings PICK Position With Set Reference Wizard	
	1.8	TEACHING TP PROGRAM	36
		1.8.1 Flow Chart of TP Program	36
		1.8.2 Register Setting Table	37
		1.8.3 Batch Input of Register Comments	
		1.8.4 Editing TP Program	
	1.9	ROBOT COMPENSATION OPERATION CHECK	41
2	FIXE	D FRAME OFFSET SYSTEM WITH 3D AREA SENSOR	42
	2.1	INSTALLATION AND CONNECTION OF 3D AREA SENSOR	42
	2.2	USER FRAME SETUP	43
	2.3	SETTING UP 3D AREA SENSOR DATA	
		2.3.1 Editing 3D Area Sensor Data	
		2.3.2 3D Area Sensor Configuration	
		2.3.3 Calibration Setup	
		2.3.4 Train Model	46
		2.3.5 Calibration	
		2.3.6 Checking Calibration Point	
		2.3.7 Checking Calibration Result	
		2.3.8 3D Area Sensor Setup	
	2.4	TOOL FRAME SETUP	
	2.5	SEARCH VISION PROCESS SETUP	
		2.5.1 Editing Vision Process	
		2.5.2 Command Tool Teaching	
		2.5.2.1 Teaching the 3D data preprocess tool	
		2.5.2.2 Teaching snap tool	
		2.5.2.3 Creating and teaching the GPM locator tool	
		2.5.2.5 Teaching the offset data calculation tool	
	2.6	CREATING TP PROGRAM	
	2.0	2.6.1 Flow Chart of TP Program	
		2.6.2 Register Setting Table	
		2.6.3 Creating and Teaching TP Program	
	2.7	ROBOT COMPENSATION OPERATION CHECK	
Re	feren	ces	
1	FRA	ME SETUP REFERENCE	61
	1.1	FRAME SETTING WITH A POINTER TOOL	61
		1.1.1 User Frame Setting	
		1.1.1.1 TCP set up	
		1.1.1.2 Setting method types and procedures	
		1.1.2 Tool Frame Setting	
	1.2	FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION	88
		1.2.1 Setup Procedures	
		1.2.2 Mounting the Calibration Grid	
		1.2.3 Setting the Parameters	
		1.2.4 Teach the Start Position	
		1.2.5 Run Measurement	95
2	CAM	ERA CALIBRATION REFERENCE	97

	2.1	ROBO	OT-GENERATED GRID CALIBRATION	
		2.1.1	Selecting and Mounting the Target	
		2.1.2	Creating a 3D Area Sensor Data	
		2.1.3	3D Area Sensor Configuration	
		2.1.4	Calibration Setup	
		2.1.5	Train Model	
		2.1.6	Calibration	
		2.1.7	Checking Calibration Point	
		2.1.8	Checking Calibration Result	
		2.1.9	Automatic Recalibration	108
3	3D A		ENSOR REFERENCE	
	3.1	3D AF	REA SENSOR GUIDANCE	
		3.1.1	Standard Layout	
		3.1.2	Camera Calibration	
		3.1.3	Projection FOV and Standoff of Projector Unit	
		3.1.4	FOV of Cameras	
		3.1.5	Ambient Lights	
	3.2		ERAL DESCRIPTION OF 3D AREA SENSOR FRATURES	
		3.2.1	3D Detection with Only 3D Map	
			3.2.1.1 3D Peak Locator Tool	
			3.2.1.2 3D Blob Locator Tool	
			3.2.1.3 3D One-Sight-Model Locator Tool	115
			3.2.1.4 3D Cylinder Locator Tool	
			3.2.1.5 3D Gripper Finger Locator Tool	
		3.2.2	3D Detection with Combination of 2D Locator Tool and 3D Map	
		3.2.2	3.2.2.1 3D COG measurement tool	
			3.2.2.2 3D plane measurement tool	
			3.2.2.3 3D Obstruction Measurement Tool	
			3.2.2.4 3D Box Locator Tool	
	3.3	UNMF	EASURABLE PARTS	
	3.4		IP PROCEDURES OF 3D AREA SENSOR	
	5.4	3.4.1	Adjusting the Layout of 3D Area Sensor	
		3.4.1	Adjusting the Focus of the Projector Unit	
		3.4.2	Adjusting the Focus of the Camera Unit	
		3.4.4	Adjusting the Conditions for Acquiring a 3D Map	
		3.4.4	3.4.4.1 Confirming the condition of the area where 3D points are not acquired	
			3.4.4.2 Adjusting the exposure time	
			3.4.4.3 Adjusting the intensity	
	3.5	MACF	RO PROGRAMS	
4	INTE	PEEDE	ENCE AVOIDANCE REFERENCE	120
_	4.1		C OPERATION FOR INTERFERENCE SETUP	_
	7.1	4.1.1	Operation for Interference Setup Data	
		7.1.1	4.1.1.1 Creating new data	
			4.1.1.2 Editing	
			4.1.1.3 Copying	
			4.1.1.4 Deleting	
			4.1.1.5 Renaming	
		4.1.2	Operating Objects	132
			4.1.2.1 Creating new data	
			4.1.2.2 Renaming	
			4.1.2.3 Deleting	
			4.1.2.4 Moving data up and down	134

	4.2	INTER	RFERENCE SETUP (SYSTEM)	134
		4.2.1	Setting of User Frame Number and Container	134
		4.2.2	Setting of Fixed Object Data	
			4.2.2.1 Spherical fixed object	
			4.2.2.2 Cylindrical fixed object	136
			4.2.2.3 Hexahedron shaped fixed object	137
			4.2.2.4 3D map fixed object	138
	4.3	INTER	RFERENCE SETUP (ROBOT)	139
		4.3.1	Setting the Tool Object	
			4.3.1.1 Spherical tool object	
			4.3.1.2 Cylindrical tool object	
			4.3.1.3 Hexahedron shaped tool object	
	4.4	INTER	RFERENCE SETUP (CONDITION)	
		4.4.1	Setting of Data Type	
		4.4.2	Setting of Interference Check	
		4.4.3	Setting of Wall Avoidance	
		4.4.4	Setting of Interference Avoidance	
	4 =			
	4.5		L PROGRAM OF INTERFERENCE AVOIDANCE	
5	PAR	TS LIS	T MANAGER REFERENCE	.150
	5.1	BASIC	C OPERATIONS OF PARTS LIST MANAGER	150
		5.1.1	Setting Type	150
		5.1.2	Displaying the Desired Edit Screen of Parts List Manager	153
	5.2	BASIC	C RULES OF PARTS LIST MANAGER	154
	5.3		S LIST MANAGER SETUP AND PART DATA OPERATIONS	
	5.5	5.3.1	Clear All Part Data in a Parts List	
		3.3.1	5.3.1.1 Call BINPICK_CLEAR in a TP program	
		5.3.2	Push Some Part Data to a Parts List	
		3.3.2	5.3.2.1 Setting up the SEARCH Vision Process	
			5.3.2.2 Set up the parameters for deleting older part data when part data are pushe	
			5.3.2.3 Duplication check	
			5.3.2.4 Call BINPICK_SEARCH in a TP program	
		5.3.3	Pop a Part Data from a Parts List	
		3.3.3	5.3.3.1 Call BINPICK_POP in a TP program	
		5.3.4	Calculate a PICK Position	
		3.3.4	5.3.4.1 Set up the parameters for calculating a PICK position	100 160
			5.3.4.2 Set the parameters for calculating a robot position to approach a part	
			5.3.4.3 Set up the Reference PICK position	
			5.3.4.4 Call BINPICK_GETPICKPOS in a TP program	
		5.3.5	Set a Status for Popped Part Data	
		3.3.3	5.3.5.1 Set up the process when setting a status for a part data	
			5.3.5.2 Call BINPICK_SETSTAT in a TP program	
		5.3.6	Calculate a FINE Position	
		3.3.0	5.3.6.1 Set up the parameters for calculating a FINE position	
			5.3.6.2 Set up the reference FINE position	
			5.3.6.3 Call BINPICK_GETFINEPOS in a TP program	
		5.3.7	Execute a FINE Vision Process for a Popped Part Data	
		0.0.7	5.3.7.1 Set up the parameters for executing a FINE vision process	
			5.3.7.2 Call BINPICK_FINE in a TP program	
	5.4	PART	DATA MONITOR	
	5.5		REFERENCE WIZARD	
	0.0	5.5.1	Basic Flow of Set Reference Wizard Operations	
		5.5.2	Details of Each Teaching Operation	
		5.5.2	5.5.2.1 Vision Execution screen	
			5.5.2.2 Reference Data Setup screen	102

c-4 B-83914EN-6/02

	5.6	KAREL	5.5.2.3 PROG	Reference position setup screen	
		5.6.1 5.6.2	KAREL	Programs of Parts List Manager Programs for Customizing the Parts List	184
Ad	vance	ed Set	up		
1	BIN F	PICKING	G CON	FIG	197
	1.1	INTER	FEREN	CE AVOIDANCE CONFIGURATION	. 198
	1.2	PARTS	S LIST M	MANAGER CONFIGURATION	. 199
2	CUST	COMIZA	MOITA		201
	2.1			TOMIZE WHEN THE CONTAINER POSITION MOVES	
	۷.۱	2.1.1		the Container Object in the Interference Setup Data According to the	
		2.1.1		of Container Travel	
		2.1.2		the Search Window According to the Amount of Container Travel	
	2.2	HOW 1	•	TOMIZE TO REDUCE PROCESSING TIME	
		_			204
		2.2.1		1 Image Register	
	2.3		_	TOMIZE TO EXECUTE THE SEARCH PROCESS IN THE	
	2.0			D PROCESS	
		2.3.1		ring System With 3D Area Sensor	
		2.3.1	2.3.1.1	Process Flow	
			2.3.1.2	Register setting table	
			2.3.1.3	Batch input of register comments	
			2.3.1.4	Copying TP programs	211
			2.3.1.5	Editing the main program	
			2.3.1.6	Checking subprograms	
		0.2.0	2.3.1.7	Checking operation	
		2.3.2		rame Offset System With 3D Area Sensor Process Flow	
			2.3.2.1 2.3.2.2	Register setting table	
			2.3.2.2	Creating and teaching TP program	
			2.3.2.4	Checking operation	
	2.4	HOW 1		TOMIZE BIN PICKING SYSTEM WITH MULTIPLE	
					223
		2.4.1		g a Container	
		21	2.4.1.1	Changing the number of parts list	
			2.4.1.2	Setting up 3D area sensor data	
			2.4.1.3	Setup of interference avoidance data	224
			2.4.1.4	Search vision process setup	
		2.4.2	2.4.1.5	Setup of parts list manager	
		2.4.2		Flow	
		2.4.3		Setting Table	
		2.4.4	Creating	g and Teaching TP Program	228
Аp	pendi	X			
Α	TROL	JBLESI	нооті	NG	237
•	A.1	_		(AREL PROGRAMS FOR INTERFERENCE AVOIDANCE	_
		CAUSE	ES AN A	LARM	. 237
	A.2			AN INTERFERING OBJECT	

B-83914EN-6/02 c-5

A.3	THE ROBOT DOES NOT PROCEED TO PICK UP A PART EVEN	
	THOUGH THE PART IS DETECTED	. 239
A.4	THE ROBOT PROCEEDS TO PICK UP A PART WHERE NO PART IS	
	PRESENT	.239
A.5	THE GRID FRAME SET DOES NOT OPERATE AS EXPECTED	. 241
A.6	THERE IS AN AREA IN WHICH 3D POINTS CANNOT BE ACQUIRED.	. 242

c-6 B-83914EN-6/02

Introduction

- 1 PREFACE
- 2 OVERVIEW
- 3 CONFIGURATION AND FEATURES

Introduction 1. PREFACE

1 PREFACE

This chapter describes an overview of this manual. It should be read before operating the iRVision.

1.1 OVERVIEW OF THE MANUAL

This is a manual for the R-30*i*B Plus/R-30*i*B Mate Plus/R-30*i*B Compact Plus CONTROLLER *i*RVision. This manual describes how to operate sensor functions and create programs after completing the installation and setup of your robot. For details on how to operate the robot in normal operation, refer to "OPERATOR'S MANUAL (Basic Operation) B-83284EN".

This manual is directed at users who have taken the "*i*RVision 3D Laser Vision Sensor course", "*i*RVision 2D Vision Sensor course" and "*i*RVision 3D Area Sensor" at FANUC Academy. For details on each setup item, refer to the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

^^ CAUTION

This manual is based on R-30*i*B Plus/R-30*i*B Mate Plus/R-30*i*B Compact Plus system software version 7DF3/06. Note that depending on the software version of your robot controller, some functions or setup items described in this manual may not exist, some functions or setup items not described in this manual may exist, and some notations may be different.

Part	Volume	Chapter title	Description
Introduction	Chapter 1	PREFACE	Describes the outline and usage of this manual and related manuals.
	Chapter 2	BIN PICKING	Describes an overview of the Bin Picking system, and the basic functions, Parts List Manager and Interference Avoidance.
	Chapter 3	CONFIGURATION AND FEATURES	Describes three examples of the Bin Picking system configuration and their features.
Basic Setup Procedures	Chapter 1	BIN PICKING SYSTEM WITH 3D AREA SENSOR	Describes the setup procedure for a Bin Picking system with 3D Area Sensor, which is the basic configuration of the Bin Picking system, from installation through operation check.
	Chapter 2	FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR	Describes the setup procedure for a Fixed Frame Offset system with 3D Area Sensor, from installation through operation check.
References	Chapter 1	FRAME SETUP REFERENCE	Describes the methods for frame setting with a pointer tool and frame setting with the Automatic Grid Frame Setting function.
	Chapter 2	CAMERA CALIBRATION REFERENCE	Describes a procedure for camera calibration based on Robot-Generated Grid Calibration.
	Chapter 3	3D AREA SENSOR REFERENCE	Describes an overview of the 3D Area Sensor, detection methods, setup procedure, macro programs, etc.
	Chapter 4	INTERFERENCE AVOIDANCE REFERENCE	Describes basic operation of the Interference Avoidance, setup details of system, robot and condition data.
	Chapter 5	PARTS LIST MANAGER REFERENCE	Describes basic operation of the Parts List Manager, setup details, work data operations, etc.

1. PREFACE Introduction

Part	Volume	Chapter title	Description
Advanced Setup	Chapter 1	BIN PICKING CONFIG	Describes the setup items for Interference Avoidance Config and Parts List Manager Config, which configure the Bin Picking system setup function.
	Chapter 2	CUSTOMIZATION	Describes how to customize your system to respond to frequently encountered situations when using a Bin Picking system, such as the container position not being determined or what to do when you would like to shorten the time necessary for SEARCH.
Appendix	А	TROUBLESHOOTING	Describes necessary troubleshooting methods for six common issues.

Symbol Used in This Manual

The following symbol is used in this manual. Use this symbol to find important information.

Symbol	Description		
<i>MEMO</i>	Describes information that provides help for operating screens, explains a function, or gives		
	information for reference.		

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.

1.2 RELATED MANUALS

This section describes other manuals that you can refer to when using iRVision.

	,	can refer to when using 1RV1sion.			
Manual	Spec. No.	Description			
OPERATOR'S MANUAL	B-83284EN	This is the main manual of the controller.			
(Basic Operation)		Setting the system for manipulating workpieces			
		Operating the robot			
		Creating and changing a program			
		Executing a program			
		Status indications			
		Backup and restore robot programs.			
		This manual is used for application design, robot installation,			
		and robot teaching.			
MAINTENANCE MANUAL	B-83195EN	This manual describes the maintenance and connection of the R-30 <i>i</i> B/R-30 <i>i</i> B Plus Controller.			
MAINTENANCE MANUAL	B-83525EN	This manual describes the maintenance and connection of the			
		R-30iB Mate/R-30iB Mate Plus Controller.			
MAINTENANCE MANUAL	B-83555EN	This manual describes the maintenance and connection of the			
		R-30iB Mate/R-30iB Mate Plus Controller (Open Air Type).			
OPERATOR'S MANUAL	B-83284EN-1	This is the alarm code list of the controllers.			
(Alarm Code List)		This manual describes the causes of alarm occurrence and the			
,		measures to be taken.			
Sensor Mechanical Unit /	B-83984EN	This manual describes the method for connecting the controller			
Control Unit		and sensors such as a camera or 3D Laser Vision Sensor used			
OPERATOR'S MANUAL		for iRVision and the sensor maintenance method.			
iRVision OPERATOR'S	B-83914EN	This manual is the reference manual for <i>i</i> RVision on the R-30 <i>i</i> B			
MANUAL		Plus/R-30iB Mate Plus/R-30iB Compact Plus controller.			
(Reference)		This manual describes each function provided by			
,		iRVision.			
		When you would like to know the meanings (i.e., items			
		on the iRVision setup screen, the arguments of an			
		instruction, and so on), refer to this manual.			
iRVision 2D Camera	B-83914EN2	This manual should first be referred to when you start up the			
Application		iRVision 2D offset and 2.5D offset systems.			
OPERATOR'S MANUAL		This manual describes procedures for starting up			
		iRVision 2D offset and 2.5D offset system, creating			
		programs, caution, technical know-how, responses to			
		several cases, and so on.			

2. BIN PICKING Introduction

2 BIN PICKING

A Bin Picking system is an application that recognizes the position and orientation of each of the parts randomly placed inside a container by using *i*RVision, and the robot to pick up those parts one by one.

This manual describes the procedures and process for building a Bin Picking system. A Bin Picking system can be built by configuring the settings according to the procedures described in "Basic Setup Procedures".

2.1 SUPPORTED FUNCTIONS

The table below shows the functions supported by Bin Picking. An overview of the functions 'Parts List Manager' and 'Interference Avoidance' listed in the table will be described later.

Some functions in the list can be used only if certain options are installed in the robot controller. Check in advance whether the functions necessary for the Bin Picking system you want to build are installed.

SUPPORTED FUNCTIONS	<i>i</i> RVision Bin Picking	iRVision 3D Area Sensor
Interference Avoidance	✓	
PARTS LIST MANAGER	✓	
3D Area Sensor-related Functions (3D Area Sensor Vision Process, etc.)		1
ROBOT-GENERATED GRID CALIBRATION		1
2-D View Vision Process Functions (2-D Single-View Vision Process, etc.)	√	
Search Area Restriction Tool	√	

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

2.2 KEY CONCEPT

This section describes terms used in this manual.

3D Area Sensor

Indicates a 3D sensor that consists of two camera units and one projector unit. The 3D Area Sensor obtains 3D information in the field of view by using the two camera units to capture multiple stripe pattern images as projected by the projector unit.

SEARCH

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

FINE

Indicates the operation of moving a robot to a predetermined position and performing 3D measurement with the 3D Laser Vision Sensor attached to the wrist of the robot based on the position of a part obtained by SEARCH. This makes it possible to obtain accurate 3D position and orientation data for each part, which cannot be measured by SEARCH with a fixed camera or hand camera.

Introduction 2. BIN PICKING

Part Data

Indicates one data set that contains the found results of SEARCH and FINE for a specific part in a container. Part data is assigned a unique ID number (part data ID), which is used for identification.

Parts List

Parts List is a list of Part Data sets. A Bin Picking system needs to be designed so that the part data of parts in one container is managed via a single parts list.

Push

Indicates operation to add part data created based on the found results of SEARCH to a parts list.

Pop

Indicates operation to select part data to be picked up preferentially, from a parts list.

Black List

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

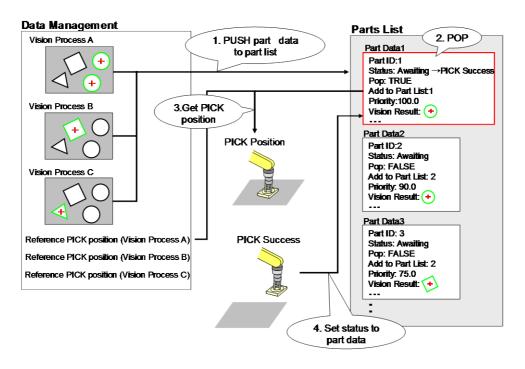
3D Map

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

2.3 PARTS LIST MANAGER

This section describes the Parts List Manager, which is a basic function of Bin Picking. The Parts List Manager is a collection of functions required for Bin Picking. By using this functionality, you can create part data based on the results found by a vision process executed as SEARCH and push that part data to a parts list.

Bin Picking using the Parts List Manager is performed mainly in the four steps shown in the following figure.



Example of Bin Picking steps using PARTS LIST MANAGER

2. BIN PICKING Introduction

Step 1 Push

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

Step 2 Pop

A candidate for part data to be picked up is selected from among the part data stored in the Parts List. At this time, a part data set whose retained priority is the highest is selected. The priority of part data is set when the part data is pushed. The user-specified measurement value of ten measurement values held in the result of detection by the vision process is set as the priority.

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

By using the found results of a vision process that are held by the popped part data (vision offset data) and the reference robot position that is held by the Parts List Manager (such as the reference PICK position and reference FINE position), the next position to which the robot should move is calculated and stored into the position register. In the above example, the part data containing the found results of vision process A are popped, so the PICK position is calculated based on the vision offset data held by this part data and the reference PICK position of vision process A held by the Parts List Manager and stored into the position register.

Step 4 Setting the status

When some operation is performed on the part corresponding to the popped part data, the status indicating the state of the part is set to the part data, such as the success or failure of PICK and the success or failure of FINE. By setting the status as above, the state of each part in the container can become the same as the state of the corresponding part data in the Parts List to perform Bin Picking system efficiently.

Parts List Manager has the following functions in order to facilitate Bin Picking in the above four steps.

Data management function

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

Position get function

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

Reference position setting wizard function

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

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



⚠ CAUTION

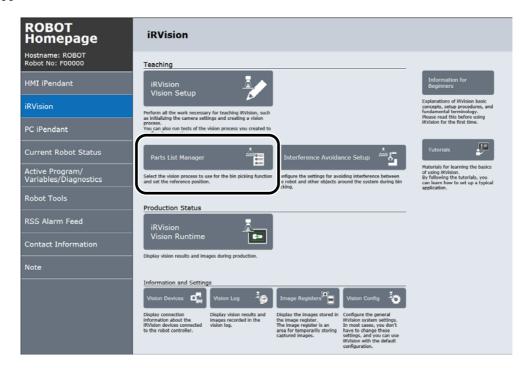
The Parts List Manager does not support the following robots: The robot with additional axes. The robot whose motion group is not group 1.

Introduction 2. BIN PICKING

2.3.1 Login to Parts List Manager

To set up the Parts List Manager, log in to the Parts List Manager.

On the ROBOT Homepage, click [iRVision], then [Parts List Manager], and the Parts List Manager screen appears.



2.4 INTERFERENCE AVOIDANCE

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

Interference Check

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

Interference Avoidance

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

Wall Avoidance

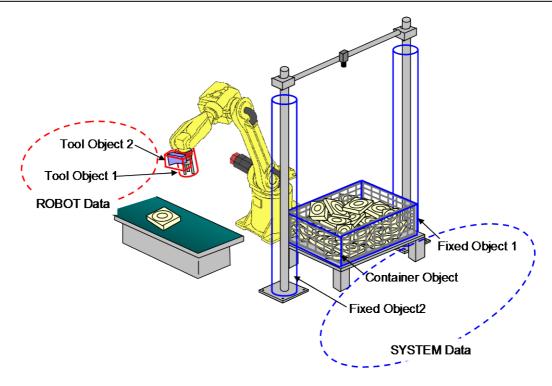
This function calculates the offset for retracting the end of the arm tooling of the robot from the wall toward the center of the container. This function is used when the robot retracts from the wall of the container after the FINE or the PICK operation.

To use the above three functions, the positions and sizes of objects for which you want to check interference should be set in advance. The positions and sizes of these objects are set by combining multiple fixed-shape objects (container, sphere, cylinder, and hexahedron) as shown in the figure below.

9 B-83914EN-6/02

2

2. BIN PICKING Introduction



Interference Avoidance

Peripheral objects such as the container and the columns of the camera stand are set as 'system data'. Among the set objects, objects other than the container are called as 'fixed objects'. Robot-mounted objects such as the gripper and the 3D Laser Vision Sensor are set as 'robot data'. The set objects are called 'tool objects'.

To perform an interference check, interference avoidance, or wall avoidance using data of these objects, conditions for such an operation are set as 'avoidance condition data'.

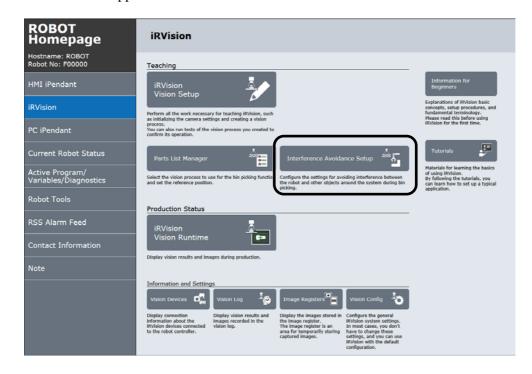


↑ CAUTION

Interference Avoidance does not support a robot with additional axes or robot whose motion group is not group 1.

2.4.1 Login to Interference Avoidance Setup

To set Interference Avoidance data, log in to the Interference Avoidance Setup screen. On the ROBOT Homepage, click [iRVision], then [Interference Avoidance Setup], and the interference avoidance data list screen appears.



3 CONFIGURATION AND FEATURES

*i*RVision supports the following bin picking systems with 3D Area Sensor.

This document explains how to set up a bin picking system with 3D Area Sensor. It also explains how to set up a fixed frame 3D offset system with 3D Area Sensor. Each system requires the software option(s) below.

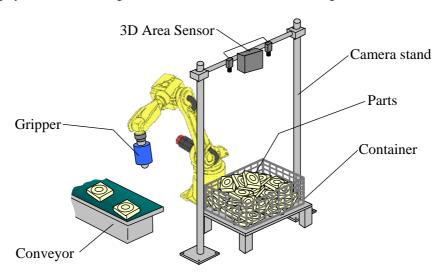
System configuration	Required software option	
Bin picking system with 3D Area Sensor	<i>i</i> RVision Bin Picking	
	iRVision 3D Area Sensor	
Fixed frame offset system with 3D Area Sensor	<i>i</i> RVision 3D Area Sensor	

This chapter explains the configurations and features of the two systems for which the set up procedures are explained in the "Basic Setup Procedures" volumes.

3.1 BIN PICKING SYSTEM WITH 3D AREA SENSOR

Configuration

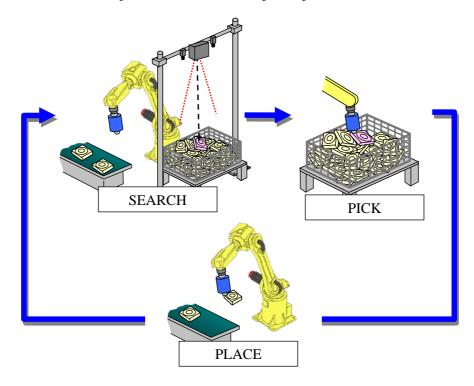
This bin picking system has a configuration such as that shown in the figure below.



Example of bin picking system configuration

Process Flow

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



Process Flow

Features

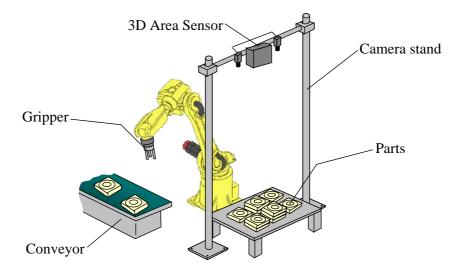
- 3D Area Sensor provides a function for measuring the 3D position and orientation of a part by using a 3D point near the part that is detected with a locator tool such as GPM Locator Tool, as well as a function for detecting the highest 3D points in a region (local peaks) and sets of 3D points (3D blob) that are continuously distributed on a 3D map. For details, refer to "References: 3 3D AREA SENSOR REFERENCE".
- In some cases a part can be picked in such a way that the direction of the gripper is consistent with the orientation of the part by using the 3D Plane Measurement Tool with a GPM locator (this depends on the shape and characteristics of the part, so it is recommended to study the applicability).
- By using the function for regional highest 3D points (local peaks) and a set of 3D points (3D blob) which are continuously-distributed on a 3D map, it is possible to achieve bin picking that does not require re-teaching in the case that shape of part will be changed (this depends on the shape and characteristics of the part, so it is recommended to study the applicability).
- 3D Area Sensor may be affected by ambient light such as ceiling lights. If the ambient light is too strong compared to the intensity of the light emitted from the projector unit to the part, the acquisition of a 3D map becomes unstable, and the number of 3D points that can be acquired is reduced.
- The Interference Avoidance function is used because it is necessary to avoid the interference between the gripper and the container.
- Part data is managed with Parts List Manager so that a part-picking process is not performed more than once on a part that can be detected with SEARCH but is placed where it cannot be picked up.

For how to set up a bin picking system with 3D Area Sensor, refer to "Basic Setup Procedures: 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR".

3.2 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR

Configuration

This fixed frame offset system has the configuration shown in the following figure.



Configuration of 3D fixed frame offset system

Features

- The Interference Avoidance function is not used for the following reasons: parts are nearly lined up, the robot will not tilt the gripper greatly during its part picking process, and the robot's work area is free from any objects that would interfere with the gripper, such as a container and a camera stand. Also, because it is a simple fixed frame offset system, the Parts List Manager is not used, either.
- 3D Area Sensor provides a function for measuring the 3D position and orientation of a part by using a 3D point near the part that is detected with a locator tool such as GPM Locator Tool, as well as a function for detecting the highest 3D points in a region (local peaks) and sets of 3D points (3D blob) that are continuously distributed on a 3D map. For details, refer to "References: 3 3D AREA SENSOR REFERENCE".
- By using the function for measuring the 3D position and orientation of a part by using a 3D point near the part that is detected with a locator tool such as GPM Locator Tool, picking operation can be performed according to the orientation of the target part (this depends on the shape and characteristics of the part, so it is recommended to study the applicability).
- By using the function for a regional highest 3D points (local peaks) and a set of 3D points (3D blob) which are continuously-distributed on a 3D map, it is possible to achieve bin picking that does not require re-teaching in the case that shape of part will be changed (this depends on the shape and characteristics of the part, so it is recommended to study the applicability).
- 3D Area Sensor may be affected by ambient light such as ceiling lights. If the ambient light is too strong compared to the intensity of the light emitted from the projector unit to the part, the acquisition of a 3D map becomes unstable, and the number of 3D points that can be acquired is reduced.

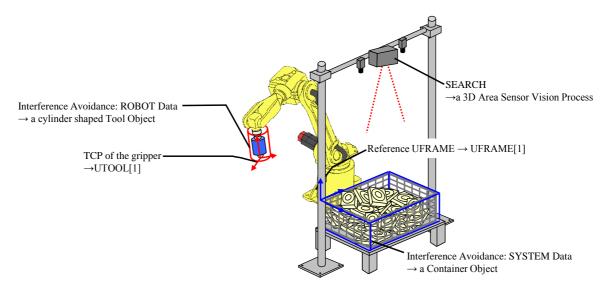
For how to set up a fixed frame offset system with 3D Area Sensor, refer to "Basic Setup Procedures: 2 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR".

Basic Setup Procedures

- 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR
- 2 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR

1 BIN PICKING SYSTEM WITH 3D AREA SENSOR

This chapter describes the specific setup procedure of the bin picking system which is set up as shown in the figure below.



Example of Bin Picking system configuration

↑ CAUTION

The position of the container is fixed and the container is not moved.

1.1 INSTALLATION AND CONNECTION OF 3D AREA SENSOR

Installation of the 3D Area Sensor

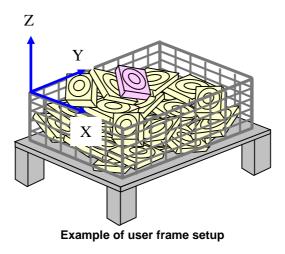
Install the 3D Area Sensor on the camera mount.

Connecting the 3D Area Sensor

Connect the 3D Area Sensor to a robot controller. For details, refer to the description of sensor connection cable configuration in "Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL B-83984EN".

1.2 USER FRAME SETUP

Set the user frame which becomes the reference frame for an offset calculation or interference avoidance calculation. Set it on the upper opening of the container as shown in the figure below. For how to set up the user frame, refer to "References: 1 FRAME SETUP REFERENCE".



Here, set the user frame to UFRAME [1] as described in the figure 'Example of Bin Picking system configuration'.

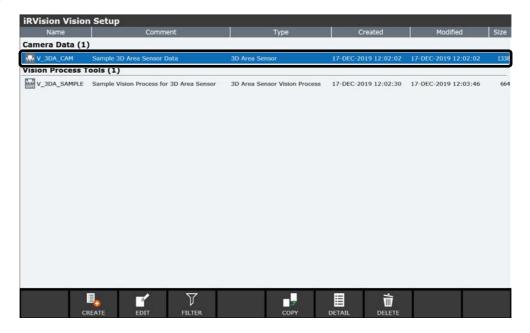
1.3 SETTING UP 3D AREA SENSOR DATA

Edit 3D Area Sensor data and configure the necessary settings according to the following procedure. On the ROBOT Homepage, click [iRVision], then [Vision Setup]. The menu screen for vision data appears.

1.3.1 Selecting 3D Area Sensor Data

The 3D Area Sensor has pre-installed sample sensor data. You should edit it according to the actual application. Edit the 3D Area Sensor data edit screen according to the following procedure:

1 Click [V_3DA_CA] from the [Camera Data] category on the vision data list screen.



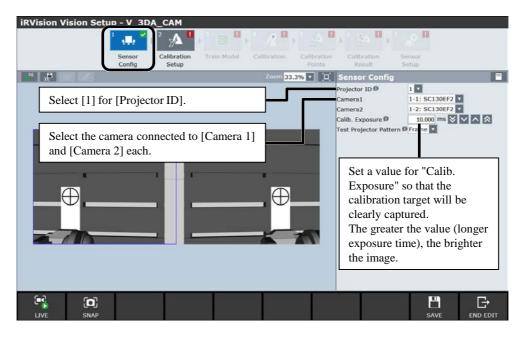
2 Click [EDIT].

The edit screen for 3D Area Sensor data is displayed.

1.3.2 3D Area Sensor Configuration

Configure the basic settings for the 3D Area Sensor.

Click [1 Sensor Config] in the navigation area of the 3D Area Sensor data edit screen. The screen below appears. Set the following parameters.



MEMO MEMO

If either of the following problems occurs, switch to the advanced mode and select [Robot-Generated Grid Cal.] for [Calibration]. (Normally, [Robot-Generated Grid Cal.] is selected)

- (1) When you want to change the initial position for [Camera1] and [Camera2] Example: The robot or gripper interferes with peripheral equipment when an initial position common to [Camera1] and [Camera2] is used.
- (2) When you want to set different targets to be used for calibration for [Camera1] and [Camera2]

Example: A target common to [Camera1] and [Camera2] is difficult to detect.

Adjusting the Layout of 3D Area Sensor

Adjust the layout of the 3D Area Sensor. For details, refer to "References: 3.4.1 Adjusting the Layout of 3D Area Sensor".

Adjusting the Focus of the Projector Unit

Adjust the focus of the projector unit of the 3D Area Sensor. For details, refer to "References: 3.4.2 Adjusting the Focus of the Projector Unit".

Adjusting the Focus of the Camera Unit

Adjust the focus of the camera units of the 3D Area Sensor. For details, refer to "References: 3.4.3 Adjusting the Focus of the Camera Unit".

1.3.3 Calibration Setup

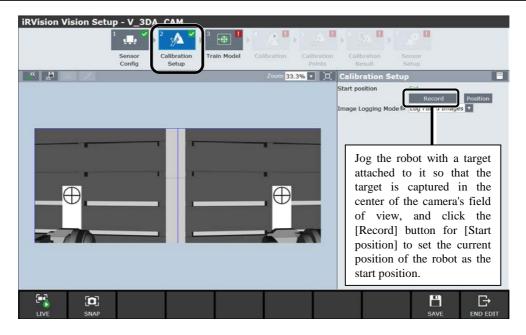
Set up calibration for two 3D area sensor cameras.

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.

Setting the Start Position

In the navigation area of the edit screen for the 3D area sensor data, click [2 Calibration Setup]. A screen similar to the one below appears. Click the [Record] button in [Start position] to record the measurement start position.



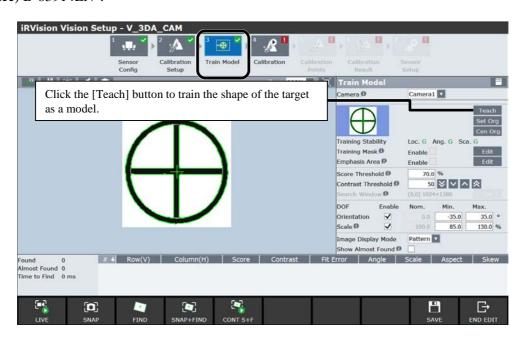
MEMO

By displaying the screen for the advanced mode and changing the settings for [Calibration Area 1] and [Calibration Area 2], you can narrow the range of the robot operation during calibration. The setting for each of these items are also reflected in [Search Window] for cameras 1 and 2 on the [Train Model] screen.

1.3.4 Train Model

Teach the model pattern for target detection.

Click [3 Train Model] in the navigation area of the 3D Area Sensor data edit screen. The screen below appears. The procedure is the same as the procedure for teaching a model pattern with GPM Locator Tool. For details, refer to the description of GPM Locator Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".



Set the value for [Run-Time Mask] for an individual camera. To limit the range to place calibration points, select the relevant camera in the drop-down box for [Camera] and then set the window.

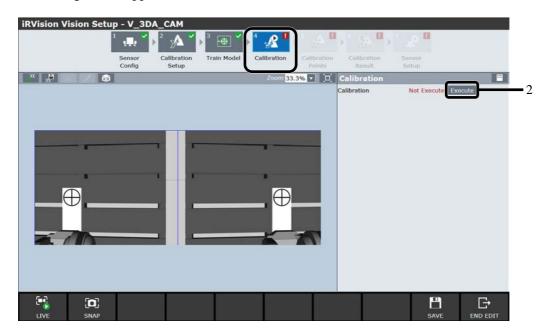
MEMO

When you display the screen for the advanced mode, you can change the [Run-Time Mask] setting.

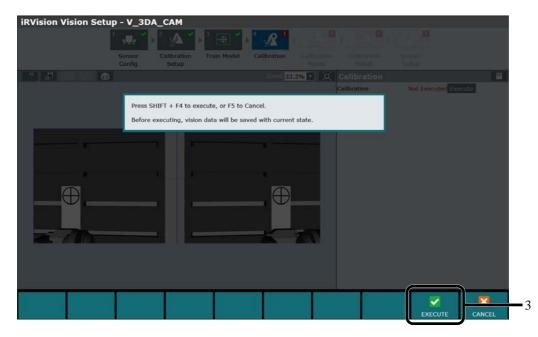
1.3.5 Calibration

Calibrate the cameras.

In the navigation area, click [4 Calibration]. The following screen appears.



- 2 Click the [Execute] button in [Calibration].
- When the following confirmation screen appears, click [EXECUTE] while holding down the [SHIFT] key on the teach pendant.

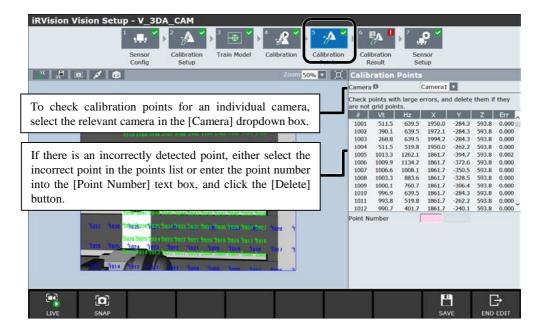


↑ CAUTION

- 1 Calibration can only be executed on the teach pendant. This action cannot be performed on the PC.
- 2 Calibration is terminated when you release the [SHIFT] key while calibration is being executed. In such cases, redo the calibration.
- 3 The robot usually performs operations within an expected range according to the parameter setting. However, the robot can move beyond the expected range depending on the parameter settings. When executing the calibration, 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.
- 4 If another program is paused, the robot may not be able to move. In such cases, press the [FCTN] key and end the programs.
- 5 When redoing a calibration that was suspended in the middle of execution, you can start from the part where it ended the last time.

1.3.6 Checking Calibration Point

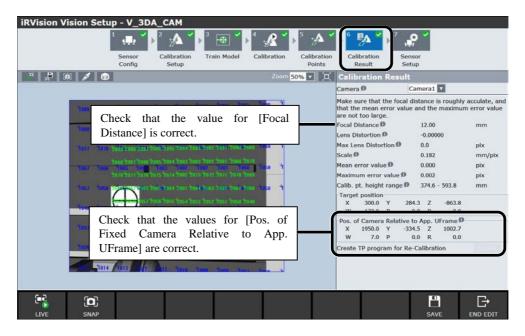
Check the found calibration points after executing Robot-Generated Grid Calibration. In the navigation area of the edit screen for the 3D area sensor data, click [5 Calibration Points]. A screen similar to the one below appears.



1.3.7 Checking Calibration Result

Check the calculated calibration data.

In the navigation area of the edit screen for the 3D area sensor data, click [6 Calibration Result]. A screen similar to the one below appears.

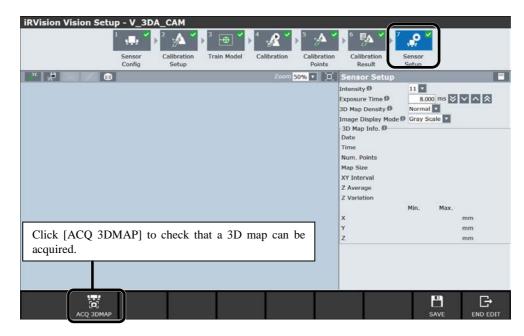


1.3.8 3D Area Sensor Setup

Set up the 3D Area Sensor according to the following procedures.

Teaching of condition of acquiring 3D Map

Click [7 Sensor Setup] in the navigation area of the 3D Area Sensor data edit screen. Set the following parameters.



Click [ACQ 3DMAP] to see if a 3D map can be acquired. If there is an area where 3D points cannot be acquired, adjust the values for [Intensity] and [Exposure Time] by referring to "References: 3.4.4 Adjusting the Conditions for Acquiring a 3D Map".

1.4 TOOL FRAME SETUP

Set a tool frame in the center of the end of the gripper claw or pad to pick up a part. This frame is useful for accurately moving the TCP of the gripper to the part gripping position.

The Z-axis of this frame should be set along the direction in which the gripper approaches a part to be picked up. The positive direction of the Z-axis should be reversed compared to the direction in which the gripper approaches a part to be picked up. To do so, change W to 180 via the direct list method after teaching the TCP.

Here, set the above tool frame to UTOOL [1] as described in the figure 'Example of Bin Picking system configuration' at the beginning of this chapter. For how to set up the tool frame, refer to "References: 1 FRAME SETUP REFERENCE".

1.5 SETUP OF INTERFERENCE AVOIDANCE DATA

Interference Avoidance data consists of Interference Setup (System) data, Interference Setup (Robot) data, and Interference Setup (Condition) data. Set up a necessary type of Interference Avoidance data.

1.5.1 Setting Interference Setup (System) Data

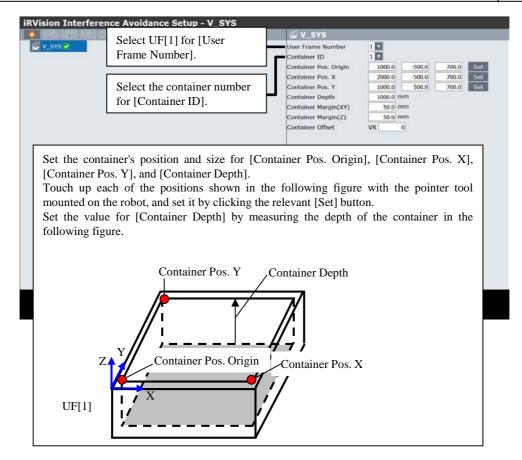
Set Interference Setup (System) data for interference avoidance.

Selecting Interference Setup (System) Data

On the ROBOT Homepage, click [iRVision], then [Interference Avoidance Setup]. The menu screen for interference avoidance appears. On the vision data list screen, select [V_SYS] and click [EDIT].

Setting a Container Object

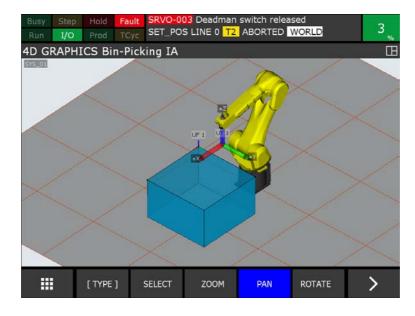
Select the Interference Setup (System) data and set the user frame and container object that form the basis for interference avoidance position calculation according to the following procedure.



Checking via 4D Graphics

After setting the container object, check that the setting has been made correctly on the 4D Graphics page on the teach pendant.

On the teach pendant, select the [MENU] key, [Next], [4D GRAPHICS], then [4D Display], and select F1[TYPE], then [4D Bin Picking IA]. In addition to the robot, the set container object is displayed in 3D graphics.



Check that the position and size of the container are correct.

1.5.2 Setting Interference Setup (Robot) Data

Set Interference Setup (Robot) data for interference avoidance.

On the ROBOT Homepage, click [iRVision], then [Interference Avoidance Setup]. The menu screen for interference avoidance appears.

Selecting the Interference Setup (Robot) Data

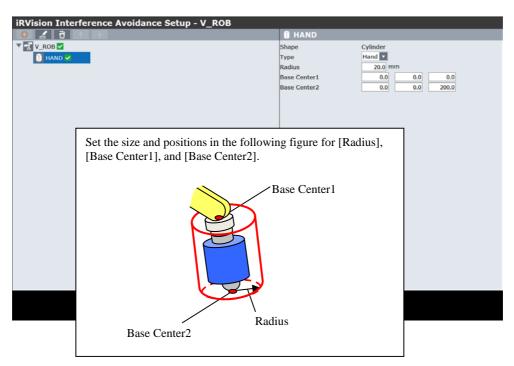
On the vision data list screen, select [V_ROB] and click [EDIT].

When the edit screen for robot data appears, select [HAND] from the tree view. It is a tool object of the robot gripper which has been set to the robot data in advance.



Setting the Tool Object

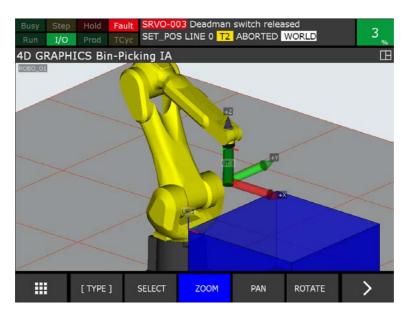
Use the following procedure to set the tool object:



Checking via 4D Graphics

After setting the tool object, check that the setting has been made correctly on the 4D Graphics page on the teach pendant.

On the teach pendant, select the [MENU] key, [Next], [4D GRAPHICS], then [4D Display], and select F1[TYPE], then [4D Bin Picking IA]. In addition to the robot, the set tool object is displayed in 3D graphics.



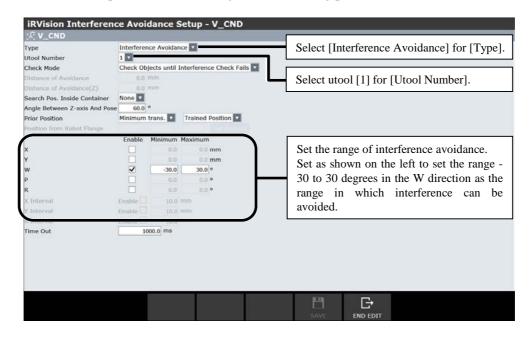
Check that the position and size of the tool object are correct.

1.5.3 Setting Interference Setup (Condition) Data

Set Interference Setup (Condition) data for interference avoidance.

On the vision data list screen, select [V_CND] and click [EDIT].

On the edit screen, set the parameters according to the following procedure.



1.6 SEARCH VISION PROCESS SETUP

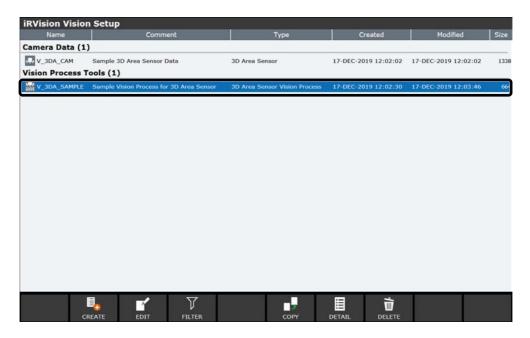
Configure the necessary settings for a vision process according to the following procedure.

On the ROBOT Homepage, click [iRVision], then [Vision Setup], and the menu screen for vision data appears.

1.6.1 Vision Process Setup

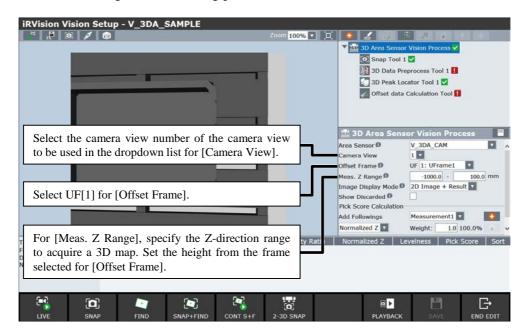
The 3D Area Sensor has a pre-installed sample vision process. You should edit it according to the actual application.

On the vision data list screen, select [V_3DA_SAMPLE] and click [EDIT].



Setting the parameters

Set the parameters for the vision process for 3D Area Sensor Vision Process. Set the parameters according to the following procedures.



1.6.2 Command Tool Teaching

Teach the 3D Data Preprocess Tool and 3D Peak Locator Tool placed in the vision process for 3D Area Sensor Vision Process.

*M***EMO**

For V_3DA_SAMPLE, Snap Tool, 3D Data Preprocess Tool, 3D Blob Locator Tool, and Offset Data Calculation Tool are placed by default. Snap Tool and Offset Data Calculation Tool will not be taught for the bin picking system, leave them as they are.

1.6.2.1 Teaching the 3D data preprocess tool

In the tree view on the vision process edit screen for 3D Area Sensor Vision Process, select [3D Data Preprocess Tool 1] and teach the 3D Data Preprocess Tool. For how to teach 3D Data Preprocess Tool, refer to the description of the 3D Data Preprocess Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

1.6.2.2 Teaching the 3D peak locator tool

In the tree view for the vision process for 3D Area Sensor Vision Process, select [3D Peak Locator Tool 1] and teach the 3D Peak Locator Tool. For details on how to teach 3D Peak Locator Tool, refer to the description of the 3D Peak Locator Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

1.7 SETUP OF PARTS LIST MANAGER

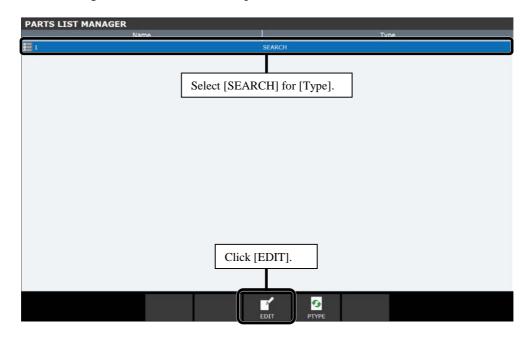
Set up the Parts List Manager.

On the ROBOT Homepage, click [iRVision], then [Parts List Manager], and the data list screen for the Parts List Manager appears.

1.7.1 Setting the Type of the Parts List Manager

Set up a parts list type.

On the Parts List Manager data list screen, select parts list [1] and click [EDIT].

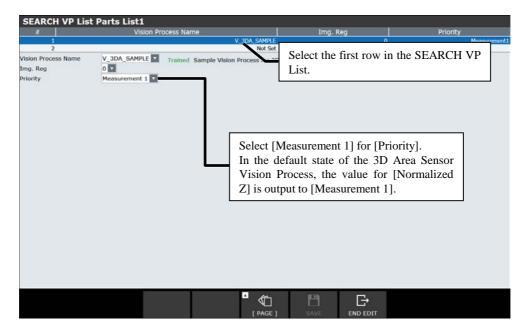


For details on how to create a new parts list or to change the type of Parts List Manager to [SEARCH + FINE], refer to "References: 5 PARTS LIST MANAGER REFERENCE".

1.7.2 Setting SEARCH VP List

Set the SEARCH vision process to the SEARCH VP List.

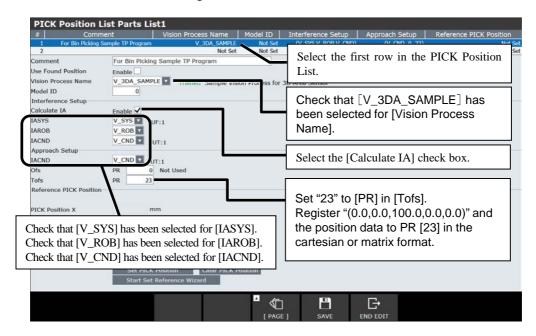
On the Parts List Manager data list screen, select the parts list to be edited and click [EDIT]. The SEARCH VP List edit screen appears. Set the parameters according to the following procedures.



1.7.3 Setting PICK Position List

Teach the reference PICK position and set it to the PICK Position List.

On the edit screen for the SEARCH VP List, select [PAGE], then [PICK Position List]. On the PICK Position List edit screen, set the following.



1.7.4 Settings PICK Position With Set Reference Wizard

Set the reference PICK position and SEARCH Vision Process reference data.

When the [Start Set Reference Wizard] button is clicked on the PICK Position List edit screen, the following screen appears. Check the setup procedure and click [NEXT].



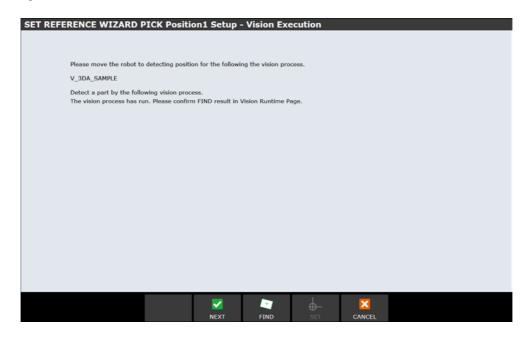
When the following screen for finding a vision process appears, move the robot out of the container by jogging it, for example, place the part at the position where you want to set as the reference position, and click [FIND].

⚠ CAUTION

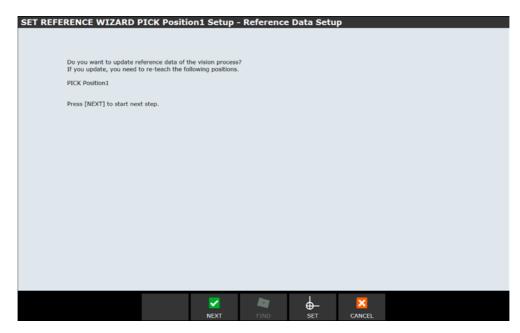
From this point onwards, do not move the part until the teaching of the robot operation is finished when the part is placed at the reference position in the TP program for fixed frame offset.



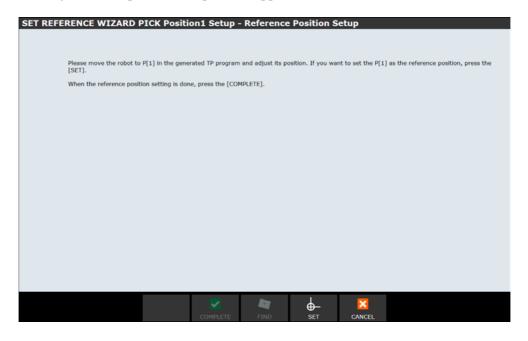
The vision process for SEARCH Vision Process is executed, and the message 'The vision process has run. Please check FIND result in Vision Runtime Page.' shown below is displayed. On the Vision Runtime screen, check that the result of the SEARCH Vision Process is correct, and click [NEXT].



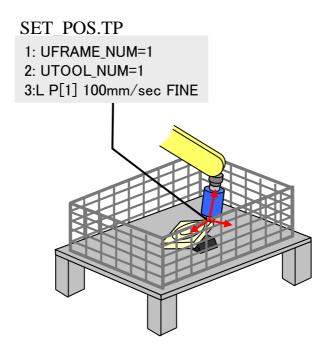
4 The following reference data setup screen appears. Click [SET] to set the reference data of the SEARCH Vision Process, and click [NEXT].



5 The following reference position setup screen appears.

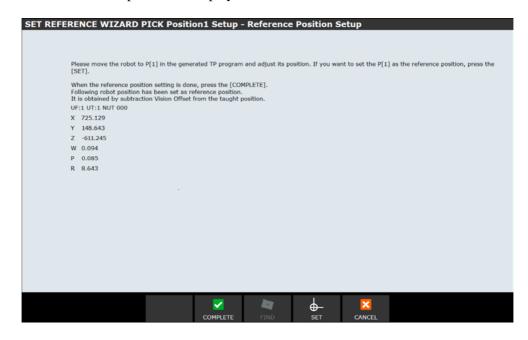


And then, the following TP program, which is "SET_POS.TP", is automatically generated. Move the robot to P [1] in the SET_POS.TP by executing the TP Program. The P [1] is automatically set to the found position of the SEARCH vision process. Confirm that the found position is on a point of a part by moving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



Position found by TP program

7 Check whether P [1] is appropriate as a position to pick a part (the position is adjusted if necessary by fine-tuning the position of the robot), and click [SET] on the Reference Position Setup screen. The set reference PICK position is displayed as follows.



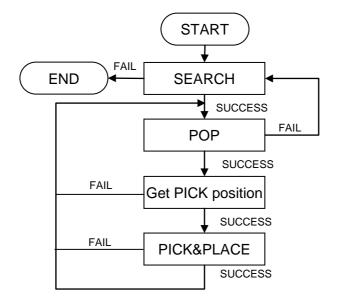
8 Check that the displayed reference PICK position is correct, and click [COMPLETE] to close the Set Reference Wizard. This will complete the reference position setting.

1.8 TEACHING TP PROGRAM

Teach the TP program for a system to perform bin picking with 3D Area Sensor.

1.8.1 Flow Chart of TP Program

The flow chart of TP program is as follows.



1.8.2 Register Setting Table

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

Registers to be used

R [10]	Status of the found result of SEARCH. The value indicates one of the				
	following states.				
	0: SUCCESS (More than one new pushed data set exists)				
	1: FAIL (No new pushed data set exists)				
R [11]	Status of the POP result. The value indicates one of the following states.				
	0: SUCCESS				
	1: FAIL (No part data that can be popped)				
R [12]	The Model ID of the popped part data				
R [13]	The status of the process to get a PICK position The value indicates one of the				
	following states.				
	0: SUCCESS				
	12: Failed to get an interference avoidance position at the PICK position				
	13: Failed to get an interference avoidance position at the approach position				

Position registers to be used

PR [20]	PICK position
PR [21]	Tool offset as the result of interference avoidance calculation related to the
	PICK position.
PR [22]	This is the Approach position.
PR [23]	Set the tool offset value from the PICK position used for approach position
	calculation.
	Example: (0.0, 0.0, 100.0, 0.0, 0.0, 0.0) in the cartesian or matrix format.

Tool frame to be used

UTOOL [1] The TCP of the gripper

User frame to be used

UFRAME [1]	Application frame

1.8.3 Batch Input of Register Comments

This system has a pre-installed sample program. By entering comments to registers and other elements used in this sample program in advance, you can check operation and modify your program easily. Although manually setting comments takes time, it will save on the labor of performing the operation.

1 Select and execute [CMT_3DA_BP] on the program list screen.



2 Check that the comments are entered as follows on the register list screen and the position register list screen.

Use Register Value

R [10]	Detection status
R [11]	Pop status
R [12]	Pop model number
R [13]	Pick status

Position registers

PR [20]	Picking
PR [21]	Pick interference offset
PR [22]	Pick approach
PR [23]	Pick approach offset

1.8.4 Editing TP Program

Edit the TP program.

1 Select [V_3DA_BP] and click [COPY] on the program list screen.



- 2 Edit the program name and click [OK].
- 3 Teach each position in the TP program.

Positions

P[1: Search]	The robot's waiting position when SEARCH is being executed. Teach a			
	position where the robot will not come into the 3D Area Sensor's field of			
	view.			
P[2: Pick Approach]	The approach position when picking the part. It is best to teach a point			
	directly above the center of the container.			
P[3: Place Approach]	The approach position when placing the part.			
P[4: Place]	The part placing position.			
P[5: Home]	The robot's waiting position. It may be the same position as P[1].			

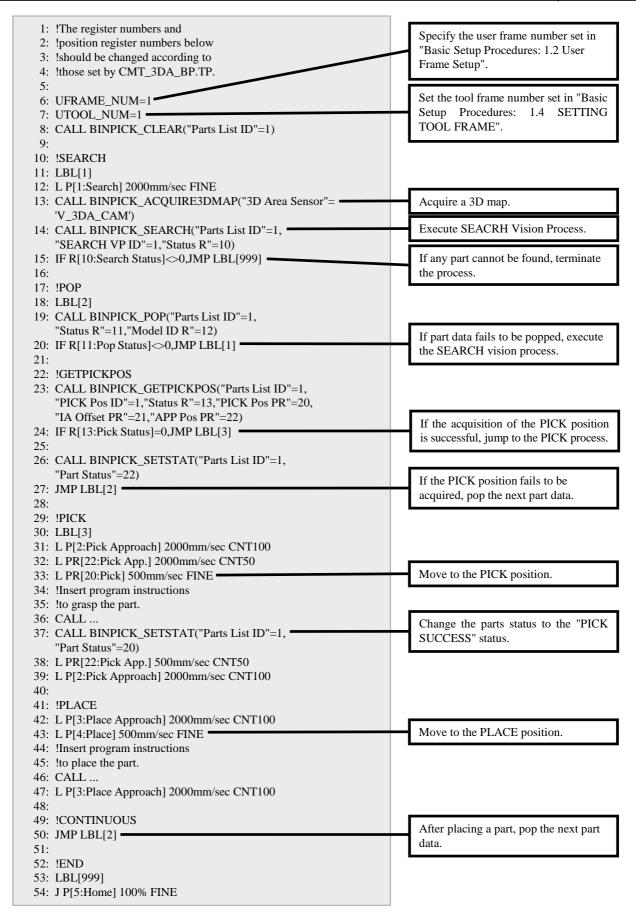
4 Add part picking and placing instructions.

For the CALL instruction in the 34th line, specify the instruction to pick up the part with the gripper. Specify the instruction according to the environment you use.

For the CALL instruction in the 43rd line, specify the instruction to release the part from the gripper. Specify the instruction according to the environment you use.

V 3DA BP.TP

This is the sample program for the Bin Picking system. For description of the macro programs such as BINPICK_CLEAR, refer to "References: 5 PARTS LIST MANAGER REFERENCE".



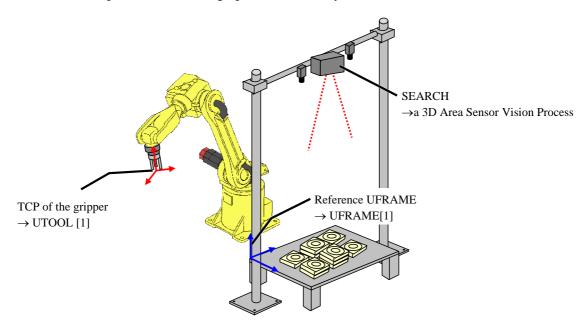
1.9 ROBOT COMPENSATION OPERATION CHECK

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

- Place a part near the reference position, detect it, and check that it can be picked up accurately. In this state, if the handling accuracy is not satisfactory, teach the reference position again.
- Move the part in the X direction or Y direction without rotation, find it and check that it can be picked up accurately.
- Rotate the part, find it and check that it can be picked up accurately.
- Find the part by placing and rotating it differently from the reference position and check that it can be picked up accurately.
- Start with lowering the 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 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR

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



Example of Bin Picking system configuration

2.1 INSTALLATION AND CONNECTION OF 3D AREA SENSOR

Installation of the 3D Area Sensor

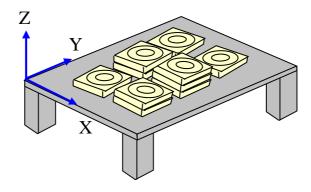
Install the 3D Area Sensor on the camera mount.

Connecting the 3D Area Sensor

Connect the 3D Area Sensor to a robot controller. For details, refer to the description of sensor connection cable configuration in "Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL B-83984EN".

2.2 USER FRAME SETUP

Set the user frame that becomes the reference frame for an offset calculation. Set it on the work table on which parts are place as shown in the figure below. For how to set up the user frame, refer to "References: 1 FRAME SETUP REFERENCE".



Example of user frame setup

Here, set the user frame to UFRAME [1] as described in the figure 'Example of Bin Picking system configuration'.

2.3 SETTING UP 3D AREA SENSOR DATA

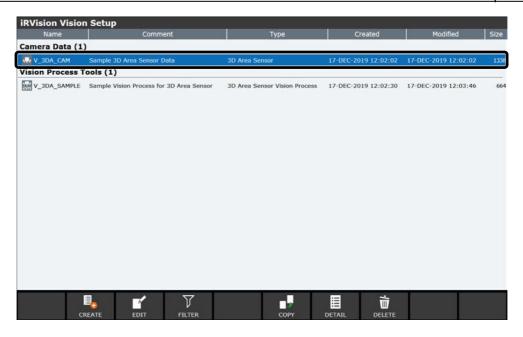
Configure the necessary settings for the 3D Area Sensor according to the following procedure. On the ROBOT Homepage, click [iRVision], then [Vision Setup]. The menu screen for vision data appears.

2.3.1 Editing 3D Area Sensor Data

The 3D Area Sensor has pre-installed sample sensor data. You should edit it according to the actual application.

Edit the 3D Area Sensor data edit screen according to the following procedure:

1 Click [V_3DA_CA] from the [Camera Data] category on the vision data list screen.



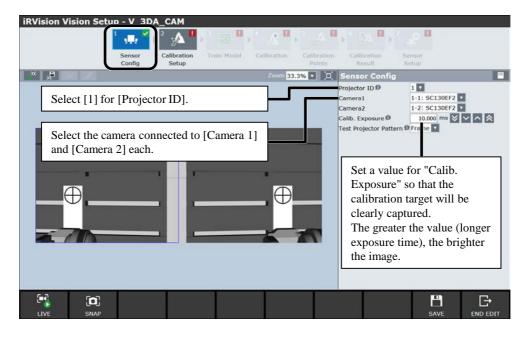
2 Click [EDIT].

The edit screen for 3D Area Sensor data is displayed.

2.3.2 3D Area Sensor Configuration

Configure the basic settings for the 3D Area Sensor.

Click [1 Sensor Config] in the navigation area of the 3D Area Sensor data edit screen. The screen below appears. Set the following parameters.



MEMO

If either of the following problems occurs, switch to the advanced mode and select [Robot-Generated Grid Cal.] for [Calibration]. (Normally, [Robot-Generated Grid Cal.] is selected)

- (1) When you want to change the initial position for [Camera1] and [Camera2] Example: The robot or gripper interferes with peripheral equipment when an initial position common to [Camera1] and [Camera2] is used.
- (2) When you want to set different targets to be used for calibration for [Camera1] and [Camera2]

Example: A target common to [Camera1] and [Camera2] is difficult to detect.

Adjusting the Layout of 3D Area Sensor

Adjust the layout of the 3D Area Sensor. For details, refer to "References: 3.4.1 Adjusting the Layout of 3D Area Sensor".

Adjusting the Focus of the Projector Unit

Adjust the focus of the projector unit of the 3D Area Sensor. For details, refer to "References: 3.4.2 Adjusting the Focus of the Projector Unit".

Adjusting the Focus of the Camera Unit

Adjust the focus of the camera units of the 3D Area Sensor. For details, refer to "References: 3.4.3 Adjusting the Focus of the Camera Unit".

2.3.3 Calibration Setup

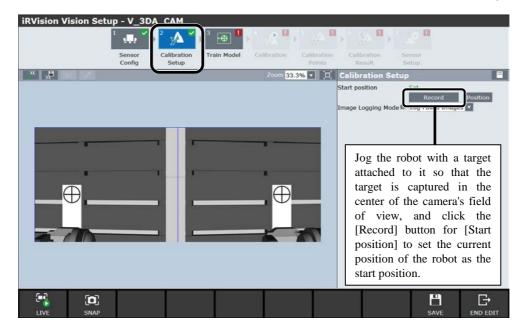
Set up calibration for two 3D area sensor cameras.

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.

Setting the Parameters

In the navigation area of the edit screen for the 3D area sensor data, click [2 Calibration Setup]. A screen similar to the one below appears. Set the following parameters.



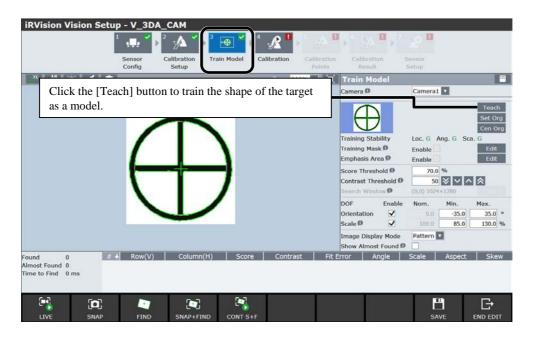
MEMO

By displaying the screen for the advanced mode and changing the settings for [Calibration Area 1] and [Calibration Area 2], you can narrow the range of the robot operation during calibration. The setting for each of these items are also reflected in [Search Window] for cameras 1 and 2 on the [Train Model] screen.

2.3.4 Train Model

Teach the model pattern for target detection.

Click [3 Train Model] in the navigation area of the 3D Area Sensor data edit screen. The screen below appears. The procedure is the same as the procedure for teaching a model pattern with GPM Locator Tool. The procedure is the same as the procedure for teaching a model pattern with GPM Locator Tool's. For details, refer to the description of GPM Locator Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".



Set the value for [Run-Time Mask] for an individual camera. To limit the range to place calibration points, select the relevant camera in the drop-down box for [Camera] and then set the window.

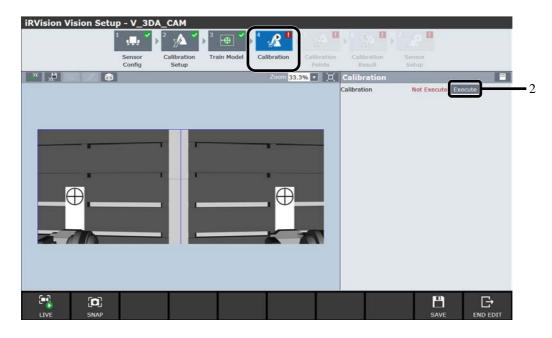
MEMO

When you display the screen for the advanced mode, you can change the [Run-Time Mask] setting.

2.3.5 Calibration

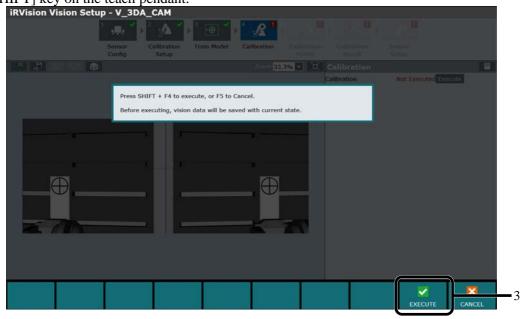
Calibrate the cameras.

In the navigation area, click [4 Calibration]. The following screen appears.



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

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

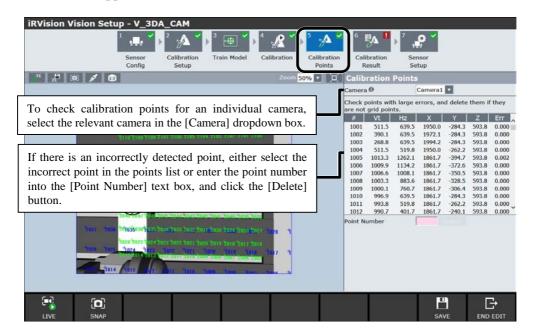


⚠ CAUTION

- 1 Calibration can only be executed on the teach pendant. This action cannot be performed on the PC.
- 2 Calibration is terminated when you release the [SHIFT] key while calibration is being executed. In such cases, redo the calibration.
- 3 The robot usually performs operations within an expected range according to the parameter setting. However, the robot can move beyond the expected range depending on the parameter settings. When executing the calibration, 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.
- 4 If another program is paused, the robot may not be able to move. In such cases, press the [FCTN] key and end the programs.
- 5 When redoing a calibration that was suspended in the middle of execution, you can start from the part where it ended the last time.

2.3.6 Checking Calibration Point

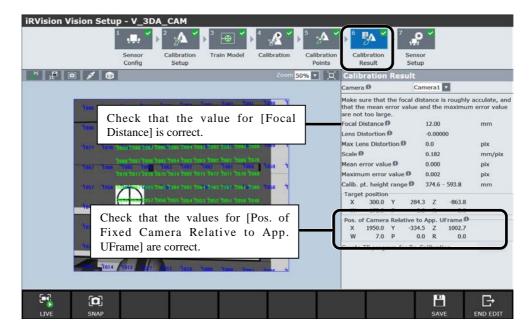
Check the found calibration points after executing Robot-Generated Grid Calibration. In the navigation area of the edit screen for the 3D area sensor data, click [5 Calibration Points]. A screen similar to the one below appears.



2.3.7 Checking Calibration Result

Check the calculated calibration data.

In the navigation area of the edit screen for the 3D area sensor data, click [6 Calibration Result]. A screen similar to the one below appears.

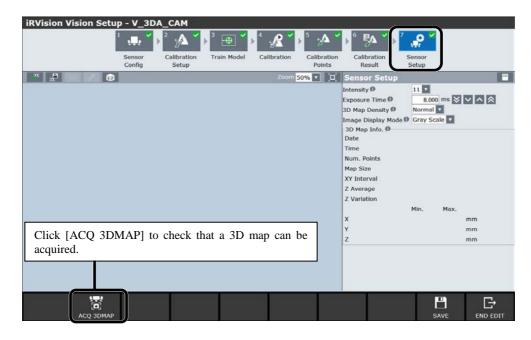


2.3.8 3D Area Sensor Setup

Set up the 3D Area Sensor according to the following procedures.

Teaching of condition of acquiring 3D Map

Click [Sensor Setup] in the navigation area of the 3D Area Sensor data edit screen. Set the following parameters.



Click [ACQ 3DMAP] to see if a 3D map can be acquired. If there is an area where 3D points cannot be acquired, adjust the values for [Intensity] and [Exposure Time] by referring to "References: 3.4.4 Adjusting the Conditions for Acquiring a 3D Map".

2.4 TOOL FRAME SETUP

Set a tool frame in the center of the end of the gripper claw or pad to pick up a part. This frame is useful for accurately moving the TCP of the gripper to the part gripping position.

The Z-axis of this frame should be set along the direction in which the gripper approaches a part to be picked up. The positive direction of the Z-axis should be reversed compared to the direction in which the gripper approaches a part to be picked up. To do so, change W to 180 via the direct list method after teaching the TCP.

Here, set the above tool frame to UTOOL [1] as described in the figure 'Example of Bin Picking system configuration' at the beginning of this chapter. For how to set up the tool frame, refer to "References: 1 FRAME SETUP REFERENCE".

2.5 SEARCH VISION PROCESS SETUP

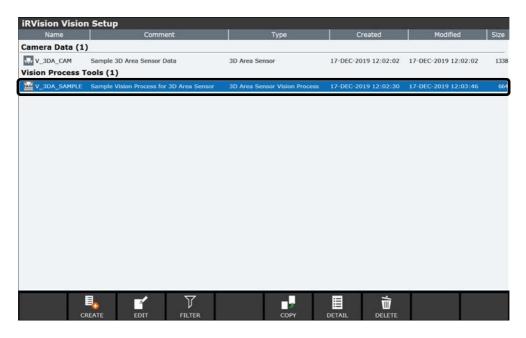
Configure the necessary settings for a vision process according to the following procedure.

On the ROBOT Homepage, click [iRVision], then [Vision Setup]. The menu screen for vision data appears.

2.5.1 Editing Vision Process

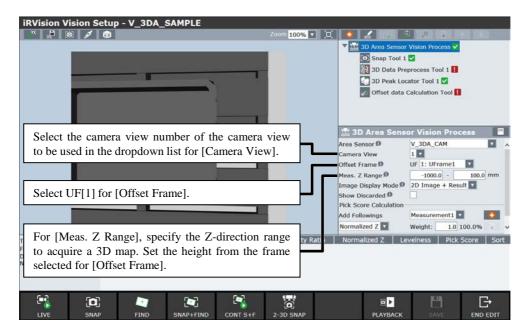
The 3D Area Sensor has a pre-installed sample vision process. You should edit it according to the actual application.

On the vision data list screen, select [V_3DA_SAMPLE] and click [EDIT].



Setting the Parameters

Set the parameters for the vision process for 3D Area Sensor Vision Process. Set the parameters according to the following procedures.



2.5.2 Command Tool Teaching

Add GPM Locator Tool and 3D Plane Measurement Tool to the 3D Area Sensor Vision Process and teach them.

MEMO

For the sample vision process, Snap Tool, 3D Data Preprocess Tool, 3D Peak Locator Tool, and Offset Data Calculation Tool are placed by default. Because 3D Peak Locator Tool is not used for the SEARCH Vision Process for the 3D offset system being set up, select 3D Peak Locator Tool from the tree view on the vision process edit screen and click the button to delete it.

2.5.2.1 Teaching the 3D data preprocess tool

In the tree view on the vision process edit screen for 3D Area Sensor Vision Process, select [3D Data Preprocess Tool 1] and teach the 3D Data Preprocess Tool. For how to teach 3D Data Preprocess Tool, refer to the description of the 3D Data Preprocess Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.5.2.2 Teaching snap tool

Select [Snap Tool 1] in the tree view to open the snap tool teaching screen. In most cases, you can use the initial settings for the sample as they are. However, if an image is too dark or bright, adjust [Exposure Time].

For details on the snap tool, refer to the description of the snap tool "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

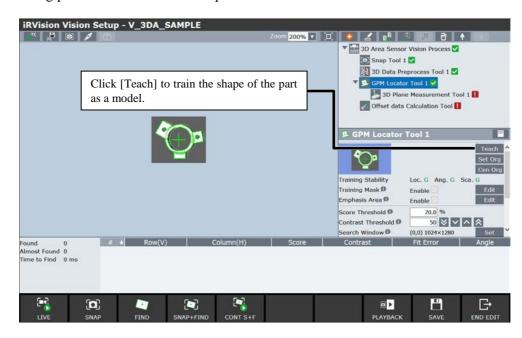
2.5.2.3 Creating and teaching the GPM locator tool

Create GPM Locator Tool in the vision process for 3D Area Sensor Vision Process according to the following procedure.

- In the tree view on the vision process edit screen, click the button. The Create new vision tool pop-up screen appears.
- 2 For [Name], enter the name of the command tool to be added.
- 3 For [Type], click [GPM Locator Tool].
- 4 Click [OK].
 - GPM Locator Tool is added.

Setting the Parameters

Set the following parameters in the item setup area for the created GPM Locator Tool.



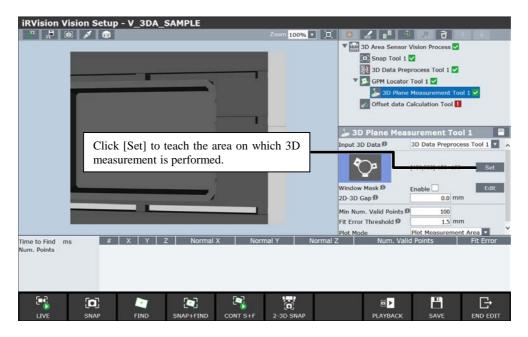
For details on how to teach GPM Locator Tool, refer to the description of GPM Locator Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.5.2.4 Teaching the 3D plane measurement tool

Add GPM Locator Tool to the vision process for 3D Area Sensor Vision Process to automatically create the 3D plane measurement tool. Set the 3D plane measurement tool according to the following procedure.

Setting the Parameters

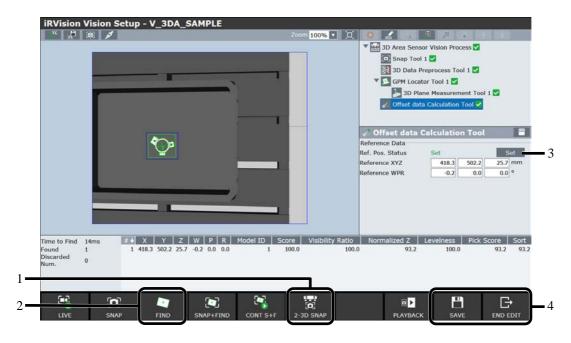
Set the following parameters in the item setup area for the created 3D Plane Measurement Tool.



For how to teach 3D Plane Measurement Tool, refer to the description of 3D Plane Measurement Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.5.2.5 Teaching the offset data calculation tool

In the tree view for the vision process for 3D Area Sensor Vision Process, select [Offset data Calculation Tool] and teach the offset data tool.



- 1 Place one part within the camera's field of view and click [2-3D SNAP].
- 2 Click [FIND] to find the part.
- 3 Check that the part has been found correctly, and click the [Set] button of [Ref. Pos. Status].
- 4 Click [SAVE] and then [END EDIT].

⚠ CAUTION

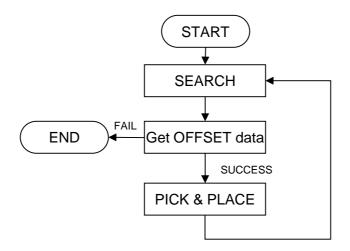
From this point onwards, do not move the part until the teaching of the robot operation is finished when the part is placed at the reference position in the TP program for fixed frame offset.

2.6 CREATING TP PROGRAM

Create a TP program for the fixed frame system with 3D Area Sensor.

2.6.1 Flow Chart of TP Program

The flow chart of the TP program is as follows.



2.6.2 Register Setting Table

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

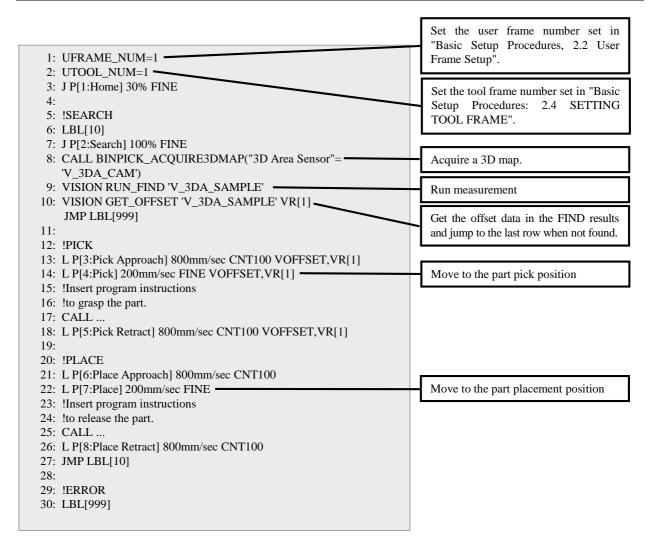
Registers to be used			
R [1]	The number of parts found by the vision process		
Vision register to be used			
VR [1]	Found results of the vision process		
Tool frame to be used			
UTOOL [1]	The TCP of the gripper		
User frame to be used			
UFRAME [1]	Application frame		

2.6.3 Creating and Teaching TP Program

Create a TP program for 3D fixed frame offset and teach positions in the program. The following shows an example of a TP program.

Position

P[1: Home]	Home position. The robot's waiting position and posture when it does nothing.			
P[2: Search]	Found position. The robot's position and posture when the sensor is finding the			
	part.			
P[3: Pick	The approach position when picking the part. In most cases, it is right above the			
Approach]	part that needs to be picked up.			
P[4: Pick]	The part pick position. It is the position at which the part is actually picked up			
	(grasped).			
P[5: Pick Retract]	The pick retraction position. It is a relay point when moving from the pick up			
	position to the placement position.			
P[6: Place	The placement approach position.			
Approach]				
P[7: Place]	The placement (part placement) position.			
P[8: Place Retract]	The place retraction position. It may be the same position and posture as P[6].			



2.7 ROBOT COMPENSATION OPERATION CHECK

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

- Place a part near the reference position, detect it, and check that it can be picked up accurately. In this state, if the handling accuracy is not satisfactory, teach the reference position again.
- Move the part in the X direction or Y direction without rotation, find it and check that it can be picked up accurately.
- Rotate the part, find it and check that it can be picked up accurately.
- Find the part by placing and rotating it differently from the reference position and check that it can be picked up accurately.
- Start with lowering the 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.

References

- 1 FRAME SETUP REFERENCE
- 2 CAMERA CALIBRATION REFERENCE
- 3 3D AREA SENSOR REFERENCE
- 4 INTERFERENCE AVOIDANCE REFERENCE
- 5 PARTS LIST MANAGER REFERENCE

1 FRAME SETUP REFERENCE

This chapter explains the setup procedures of frames. When an 'application frame' or an 'offset frame' is set, refer to this chapter. Refer to Section 3.9 "SETTING COORDINATE SYSTEMS" in the "OPERATOR'S MANUAL (Basic Function) (B-83284EN)" about a general method of frame setting. There are two methods for frame setting. Refer to the following for each setting method.

- For details on the frame setting with a pointer tool, refer to "References: 1.1 FRAME SETTING WITH A POINTER TOOL".
- For details on the frame setting with the automatic grid frame set function, refer to "References: 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 the following items.

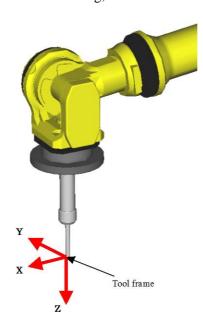
- For details on the user frame setting, refer to "References: 1.1.1 User Frame Setting".
- For details on the tool frame setting, refer to "References: 1.1.2 Tool Frame Setting".

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 TCP setup for a pointer tool in preparation.

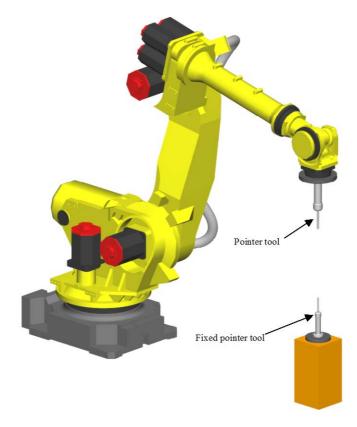
1.1.1.1 TCP set up

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 can be set as desired. 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. If the accuracy of this TCP setting is low, the precision in handling of a workpiece by the robot is also degraded.

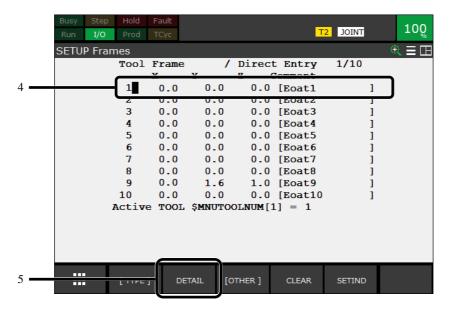


Example of a layout for pointer tool and fixed pointer tool

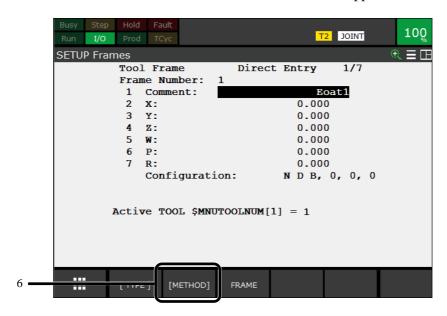
Three point method

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.

- On the teach pendant, after selecting the [MENU] key \rightarrow [SETUP], place the cursor over [Frames] and press the [ENTER] key.
- 2 Press F3 [OTHER].
- Place the cursor over [Tool Frame] and press the [ENTER] key. The list screen for tool frames will appear.

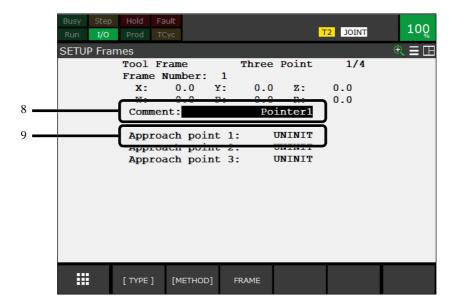


- 4 Place the cursor over the line of the tool frame number to be set.
- 5 Press F2 [DETAIL].
 The setup screen for the tool frame for the selected frame number will appear.

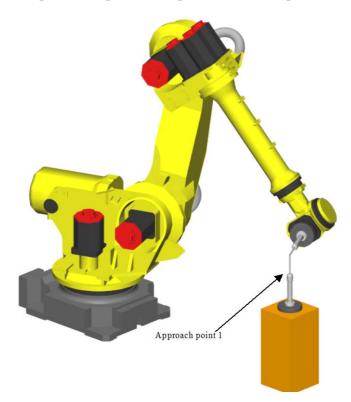


- 6 Press F2 [METHOD].
- Place the cursor over [Three Point] and press the [ENTER] key.

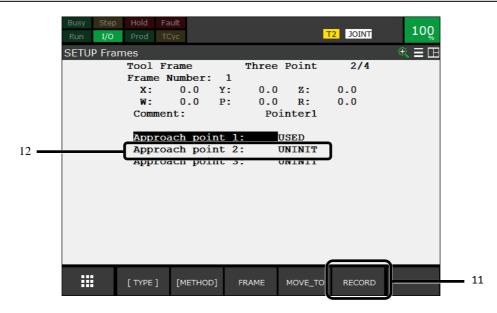
 A screen for tool frame setting using the three point teaching method will appear.



- 8 Enter a comment in the [Comment] field as required.
 A comment that distinguishes 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

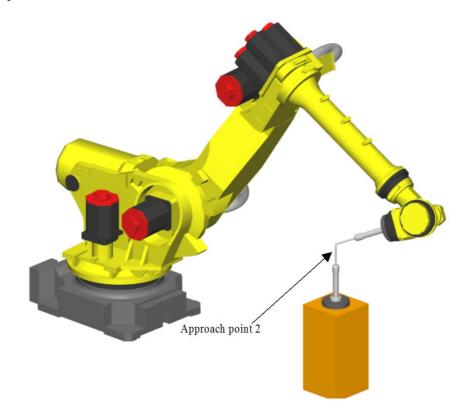


- While holding down the [SHIFT] key, press F5 [RECORD].

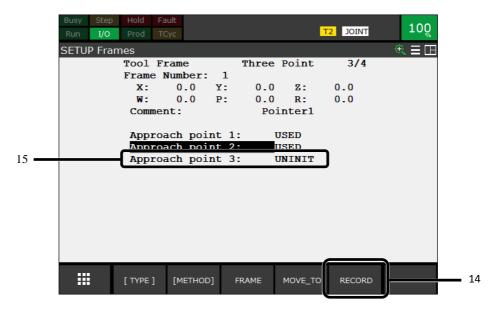
 The data of the current value is entered as an approach point.

 When the teaching has been done for [Approach point 1], [USED] is displayed for [Approach point 1].
- 12 Place the cursor over [Approach point 2].
- Jog the robot and touch up the fixed pointer tool pin with the robot pointer tool pin.

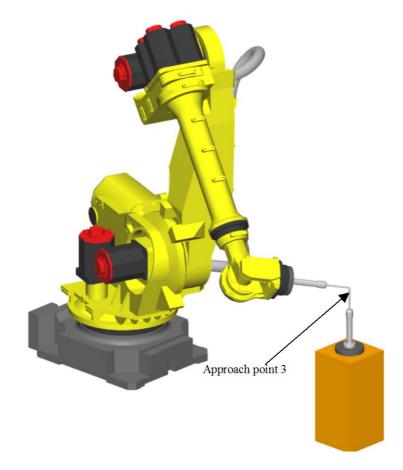
 Touch up the same point as approach point 1. However, change the robot attitude from that of approach point 1.



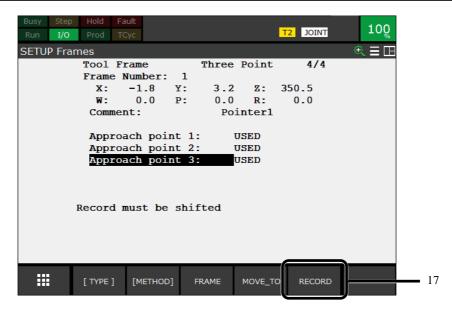
Touch-up of approach point 2



- While holding down the [SHIFT] key, press F5 [RECORD]. The current value's data will be input as approach point 2. [USED] will appear for [Approach point 2].
- 15 Move the cursor to [Approach point 3].
- Jog the robot and touch up the fixed pointer tool pin with the robot pointer tool pin. The position of approach point 3 is the same as approach point 1 and 2. However, the posture of approach point 3 is different from the posture of approach point 1 and 2.



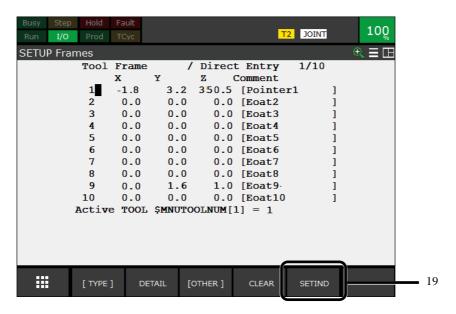
Touch-up of approach point 3



- While holding down the [SHIFT] key, press F5 [RECORD].

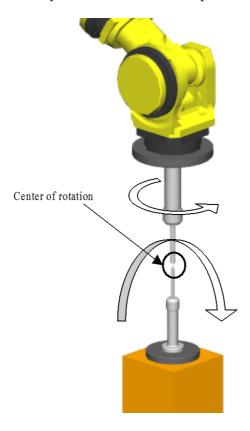
 The current value's data will be input as approach point 3. When all the approach points are taught, [USED] is displayed for all reference points. The tool frame is set.
- 18 Press the [PREV] key.

 The list screen for tool frames will appear.



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

20 Jog the robot 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

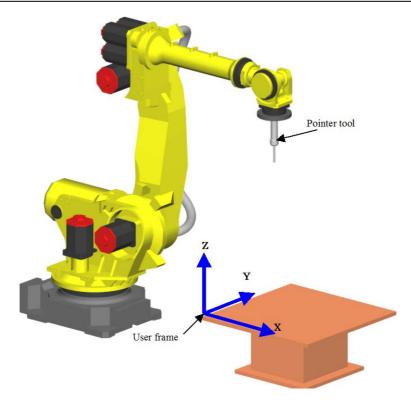
Jog the robot around the tool frame, and change the orientation of the tool (w, p, r). If the TCP is accurate, the tip of the pointer tool will always point toward the tip of the fixed pointer tool.

1.1.1.2 Setting method types and procedures

There are three methods of setting a user frame, the "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 "References: 1.1.1.1 Setting a TCP". 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" are explained as shown below.

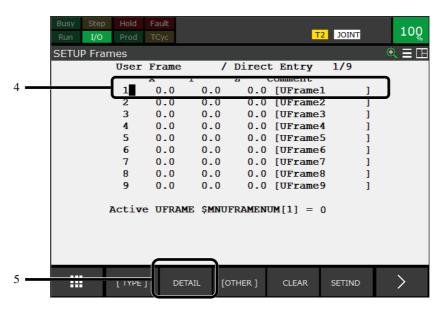
Three point method

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



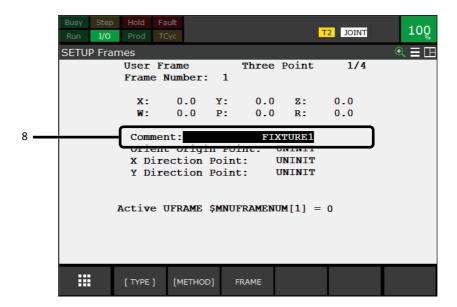
Example for setting a user frame that is parallel with a work table plane

- On the teach pendant, after selecting the [MENU] key \rightarrow [SETUP], place the cursor over [Frames] and press the [ENTER] key.
- 2 Press F3 [OTHER].
- 3 Place the cursor over [User Frame] and press the [ENTER] key. The user frame list page appears.

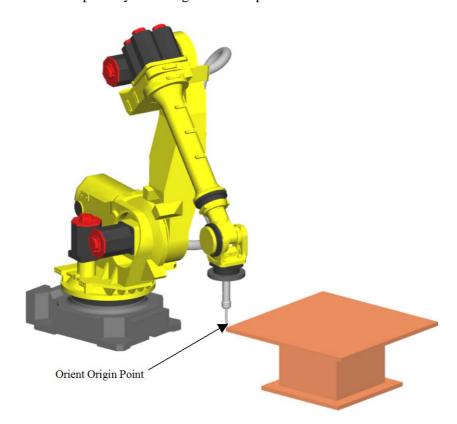


- 4 Place the cursor over the line number of the frame to be set.
- 5 Press F2 [DETAIL]. SETUP Frames screen for the selected frame will appear.
- 6 Press F2 [METHOD].
- Place the cursor over [Three Point] and press the [ENTER] key.

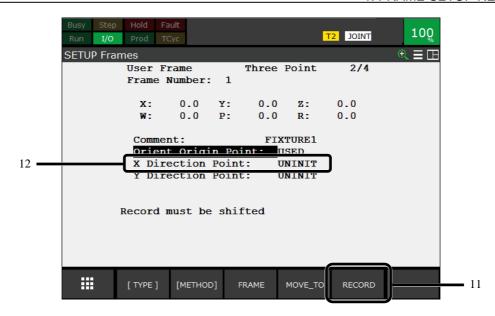
 A screen for user frame setting using the three point teaching method will appear.



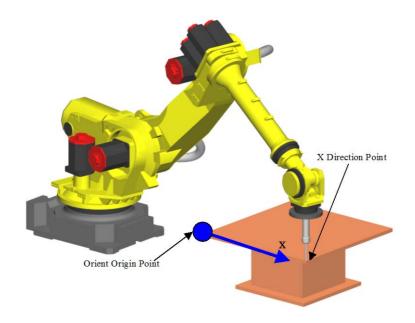
- 8 Enter a comment in the [Comment] field as required.
 A comment that distinguishes this frame from other frames is recommended.
- 9 Move the cursor to the [System Origin Point].
- 10 Jog the robot to touch up the System Origin with the pointer tool.



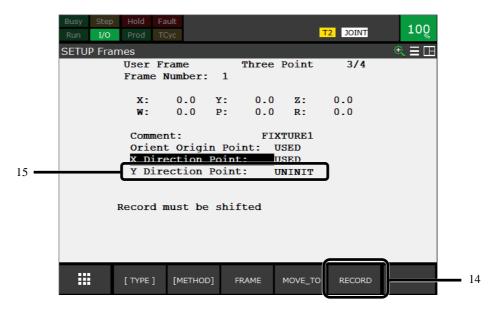
Touching up the System Origin



- While holding down the [SHIFT] key, press F5 [RECORD].
 The current position data will be recorded as the system origin of the frame.
 [USED] will appear for the taught [System Origin Point].
- 12 Move the cursor to [X Direction Point].
- Jog the robot and touch up the X direction point with the pointer tool.
 A line drawn between the system origin point and the touched up X direction point will be the X-axis of the frame.

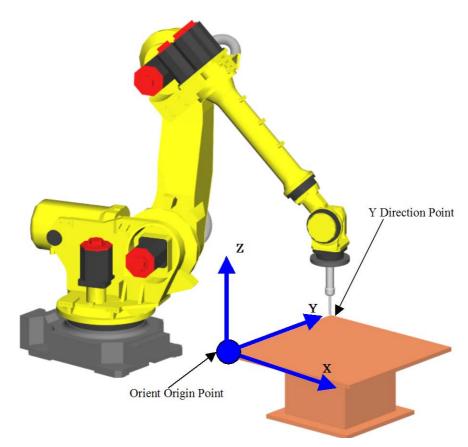


Touch-up of X direction point

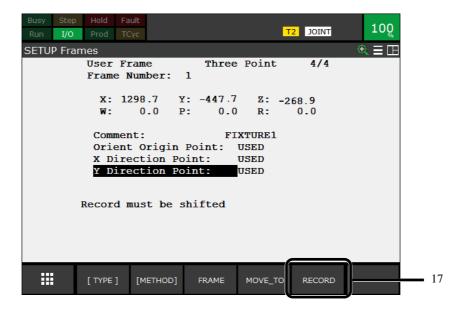


- While holding down the [SHIFT] key, press F5 [RECORD].
 The current position data will be recorded as the X direction point.
 [USED] will appear for the taught [X Direction Point].
- 15 Move the cursor to the [Y Direction Point].
- Jog the robot and touch up the Y direction point with the pointer tool.

 Touching up the Y-axis direction will determine the X and Y plane of the frame.



Touch-up of Y direction point



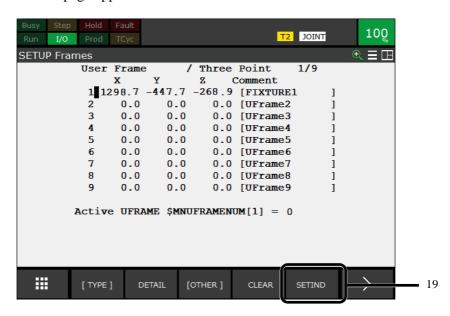
17 While holding down the [SHIFT] key, press F5 [RECORD].

The current position data will be recorded as the Y direction point.

When all the touch-up points are taught, [USED] is displayed for all of them. The user frame is set.

18 Press the [PREV] key.

The user frame list page appears.

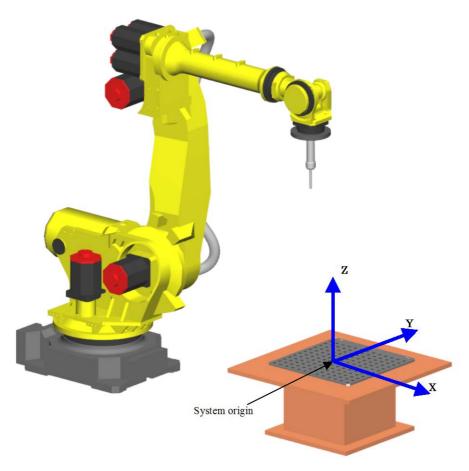


19 Press F5 [SETIND] and enter a frame number.

The user frame that has been set will be set as the currently enabled user frame.

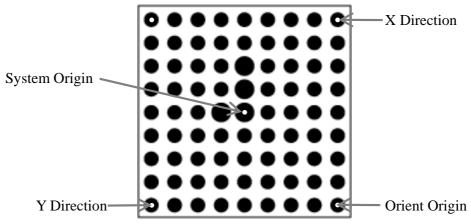
Four point method

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



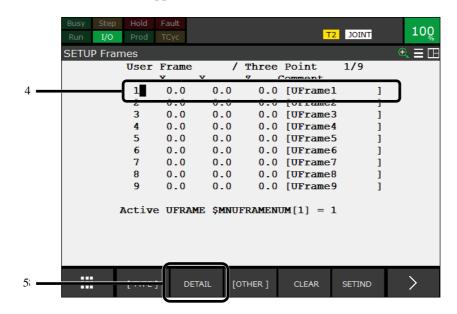
Example of setting a user frame on a fixed calibration grid

The following figure is a calibration grid. When performing 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 shorter. The accuracy of user frame setting is better when the "Four point method" is used.



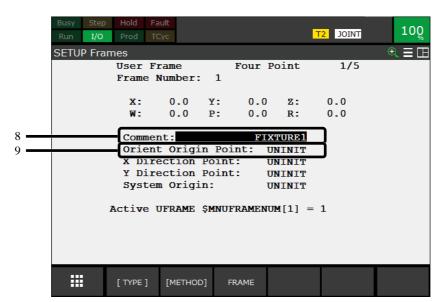
Four point teaching method touch-up points for a calibration grid

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

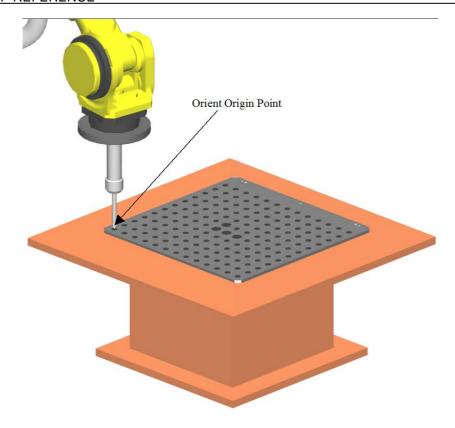


- 4 Place the cursor over the line number of the frame to be set.
- 5 Press F2 [DETAIL]. SETUP Frames screen for the selected frame will appear.
- 6 Press F2 [METHOD].
- Place the cursor over [Four Point] and press the [ENTER] key.

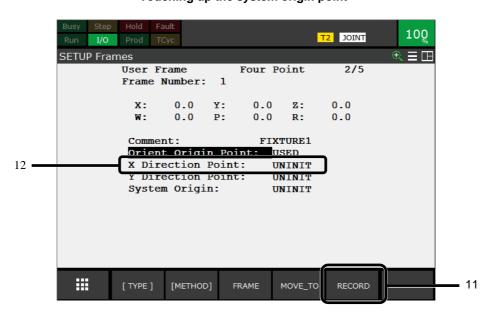
 A screen for user frame setting using the four point teaching method will appear.



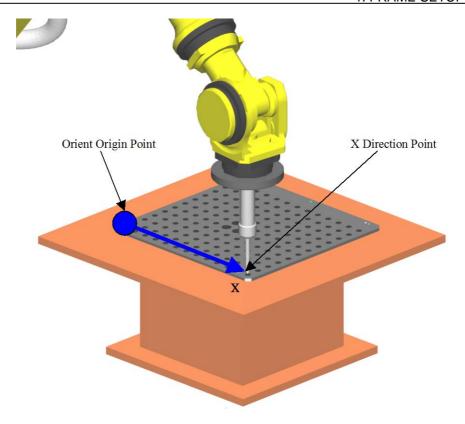
- 8 Enter a comment in the [Comment] field as required.
 A comment that distinguishes this frame from other frames is recommended.
- 9 Place the cursor over [Orient Origin Point].
- 10 Jog the robot and touch up the X direction origin point with the pointer tool.



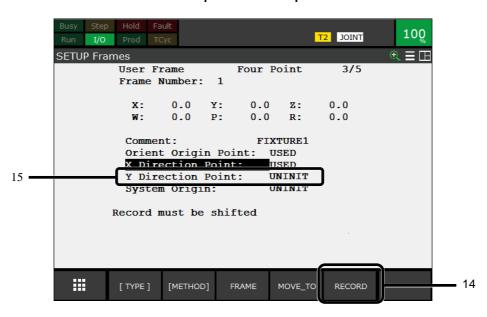
Touching up the system origin point



- 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 Move the cursor to [X Direction Point].
- Jog the robot and touch up the X direction point with the pointer tool.
 A line drawn between the system origin point and the touched up X direction point will be the X-axis of the frame.

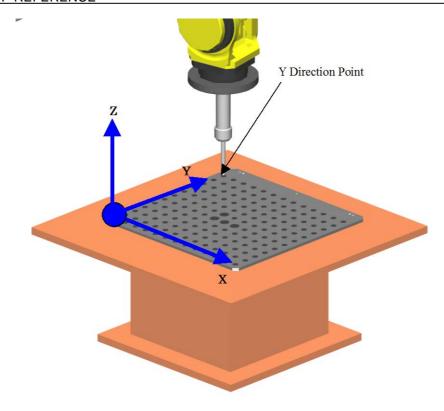


Touch-up of X direction point

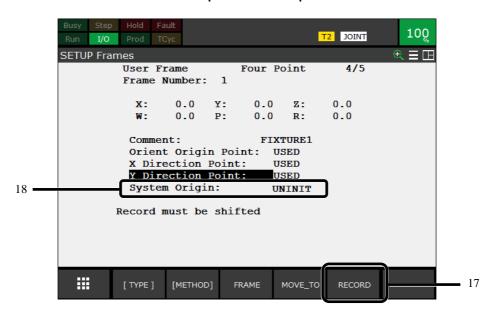


- While holding down the [SHIFT] key, press F5 [RECORD].
 The current position data will be recorded as the X direction point.
 [USED] will appear for the taught [X Direction Point].
- 15 Move the cursor to the [Y Direction Point].
- Jog the robot and touch up the Y direction point with the pointer tool.

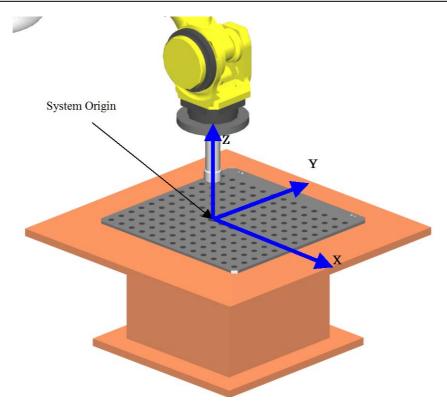
 Touching up the Y-axis direction will determine the X and Y plane of the frame.



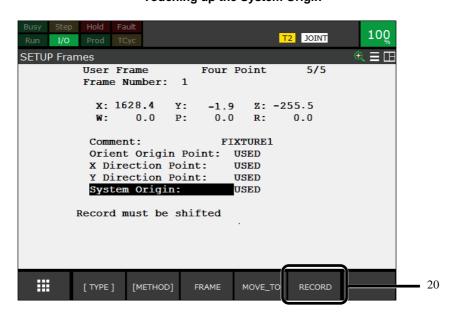
Touch-up of Y direction point



- While holding down the [SHIFT] key, press F5 [RECORD].
 The current position data will be recorded as the Y direction point.
 [USED] will appear for the taught [Y Direction Point].
- 18 Move the cursor to the [System Origin Point].
- 19 Jog the robot and touch up the system origin point of the frame with the pointer tool.



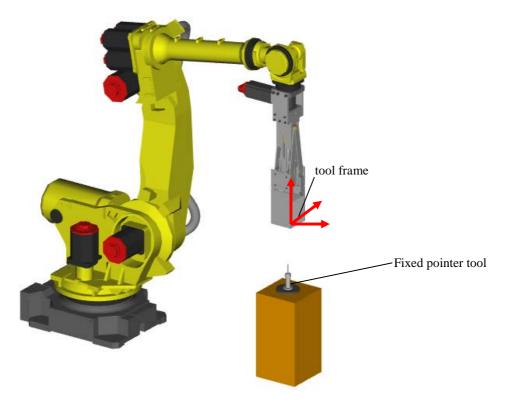
Touching up the System Origin



- 20 While holding down the [SHIFT] key, press F5 [RECORD].
 - The current position data will be recorded as the system origin of the frame.
 - When all the touch-up points are taught, [USED] is displayed for all of them. The user frame is set.
- 21 Press the [PREV] key.
 - The user frame list page appears.
- 22 Press F5 [SETIND] and enter a frame number.
 - The user frame that has been set will be set as the currently enabled user frame.

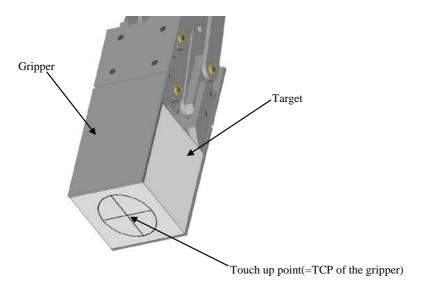
1.1.2 Tool Frame Setting

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



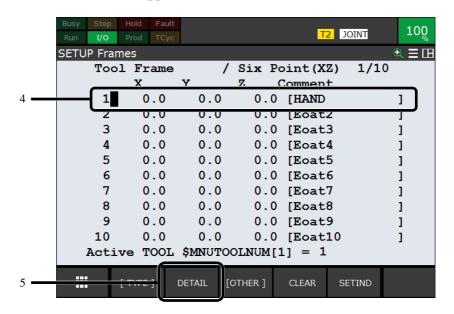
Tool frame setting example

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



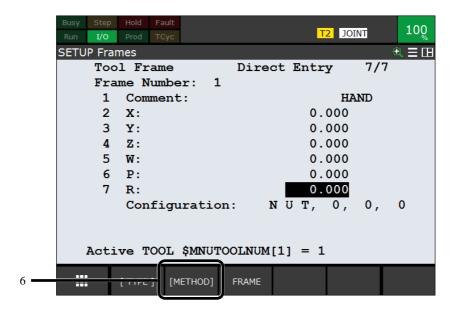
Installing the target in the robot's gripper

- On the teach pendant, after selecting the [MENU] key \rightarrow [SETUP], place the cursor over [Frames] and press the [ENTER] key.
- 2 Press F3 [OTHER].
- Place the cursor over [Tool Frame] and press the [ENTER] key. The list screen for tool frames will appear.

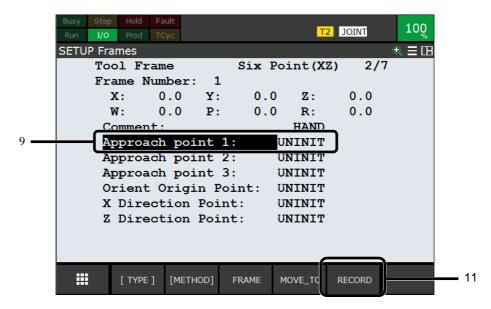


- 4 Place the cursor over the line of the tool frame number to be set.
- 5 Press F2 [DETAIL].

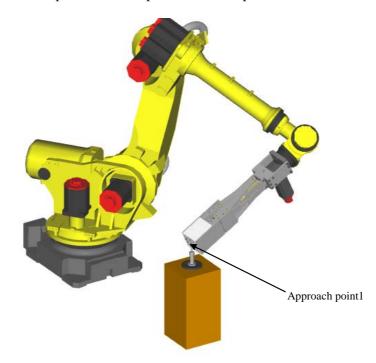
The setup screen for the tool frame for the selected frame number will appear.



- 6 Press F2 [METHOD].
- Move the cursor to [Six Point (XZ)] and press the [Enter] key. The tool frame setup page for the six point (XZ) method appears.



- 8 Enter a comment in the [Comment] field as required.
 A comment that distinguishes 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.

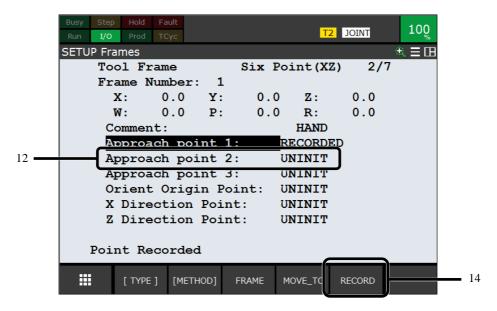


Touch-up of approach point 1

While holding down the [SHIFT] key, press F5 [RECORD].

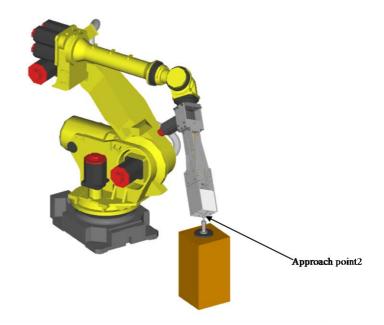
The current value's data will be input as approach point 1.

When the teaching has been done for [Approach point 1], [USED] is displayed for [Approach point 1].



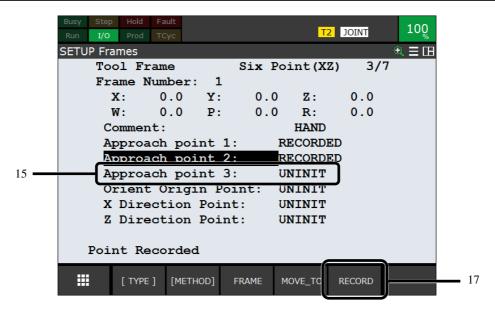
- 12 Place the cursor over [Approach point 2].
- Jog the robot and touch up the approach point 2 with the pointer tool.

 Touch up the same point as approach point 1. However, change the robot attitude from that of approach point 1.



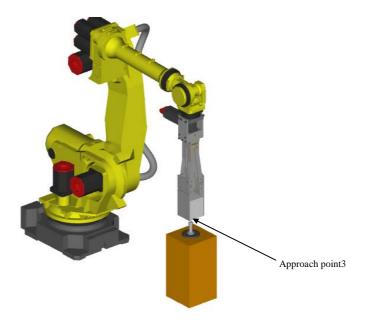
Touch-up of approach point 2

While holding down the [SHIFT] key, press F5 [RECORD]. The current value's data will be input as approach point 2. [USED] will appear for [Approach point 2].



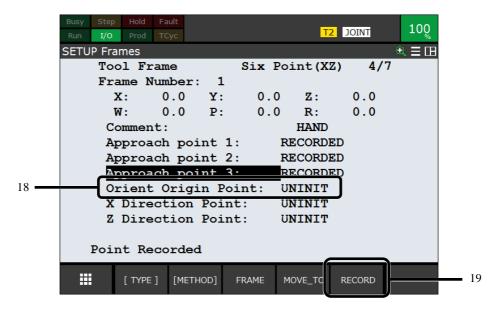
- 15 Move the cursor to [Approach point 3].
- Jog the robot and touch up the approach point 3 with the fixed pointer.

 The position of approach point 3 is the same as approach point 1 and 2. However, the posture of approach point 3 is different from the posture of approach point 1 and 2.



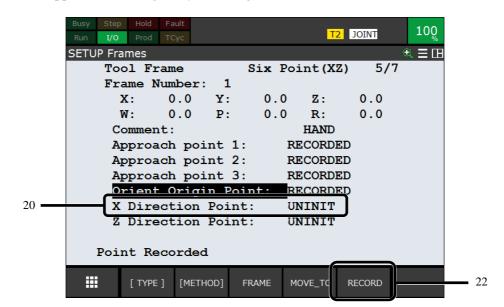
Touch-up of approach point 3

While holding down the [SHIFT] key, press F5 [RECORD]. The current value's data will be input as approach point 3. As for the taught [Approach point 3], [USED] will appear.

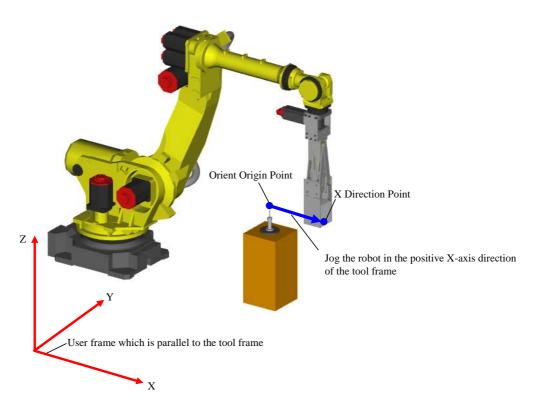


- 18 Move the cursor to the [System Origin Point].
- 19 Set the position and posture of the robot for Approach point 3 as the System Origin. While holding down the [SHIFT] key, press F5 [RECORD].

The current position data will be recorded as the system origin of the frame. [USED] will appear for the taught [System Origin Point].

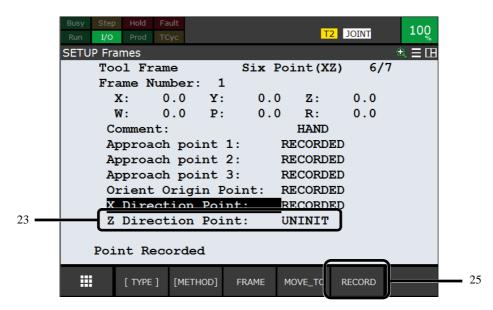


- 20 Move the cursor to [X Direction Point].
- Jog the robot so that the X Direction Point becomes a point in the positive direction of the X-axis parallel to the tool frame to be set. Then, perform teaching based on Cartesian or tool jogging so that the posture of the robot does not change.

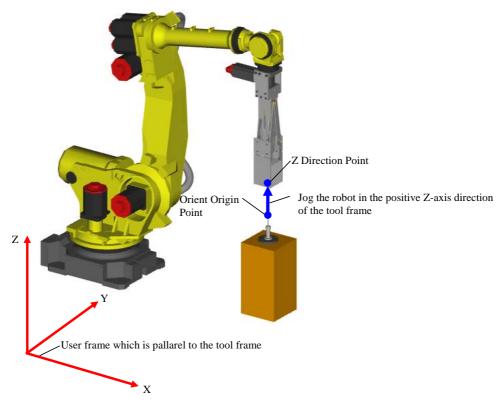


Jog the robot in the positive X-axis direction of the tool frame

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



- 23 Move the cursor to [Z Direction Point].
- Jog the robot so that the Z Direction Point becomes a point in the positive direction of the Z-axis parallel to the tool frame to be set. Then, perform teaching based on Cartesian or tool jogging so that the posture of the robot does not change.

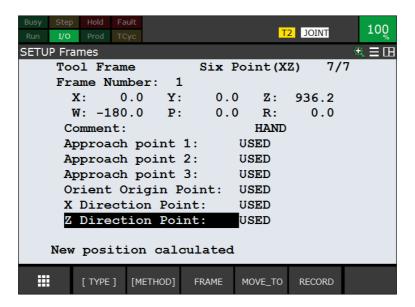


Jog the robot in the positive Z-axis direction of the tool frame

25 While holding down the [SHIFT] key, press F5 [RECORD].

The data of the current value is entered as the Z Direction Point.

When all the approach points are taught, [USED] is displayed for all reference points. The tool frame is set.



26 Press the [PREV] key.

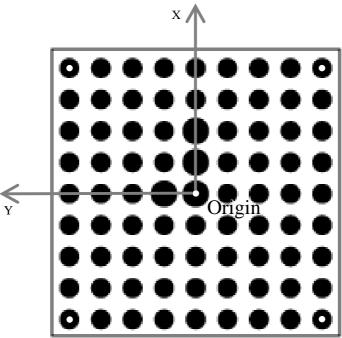
The tool frame list page appears.

- 27 Check that the TCP is set accurately. Press F5 [SETIND] and enter a frame number. The set tool frame is set as the currently effective tool frame.
- 28 Jog the robot and bring the target's reference point close to the tip of the fixed pointer tool.

Jog the robot around TCP and change the posture (w, p, r) of the target. When the reference point of the target is the center of rotation, TCP is set accurately.

1.2 FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION

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



Example of a frame using a calibration grid

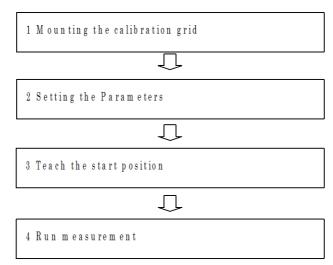
Compared with the manual touch-up setting method, the function offers a number of merits, including accurate setting of the frame without requiring user skills, no need for touch-up pointers or to set the TCP for touch-up setting, and semi-automatic easy-to-do operation.



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.

1.2.1 Setup Procedures

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

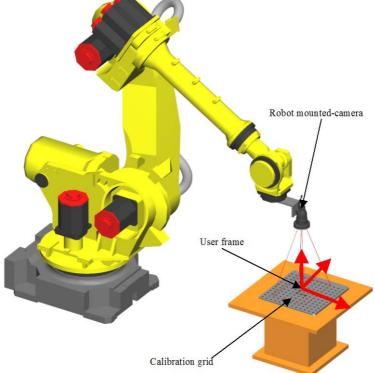


1.2.2 Mounting the Calibration Grid

This section describes how to mount a calibration grid.

When the calibration grid is secured to a fixed surface

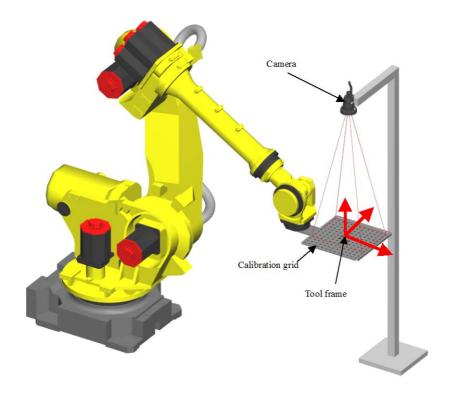
When the calibration grid is secured to fixed surface, a camera mounted on the robot end of arm tooling is used to measure the position of the calibration grid frame. The Grid Frame Setting Function identifies the position of the calibration grid frame relative to the robot base frame (world), and sets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



Example of a calibration grid secured to a fixed surface

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 enough space to perform the calibration grid frame setting function with the camera currently used, prepare another fixed camera to make it possible to perform the calibration grid frame setting function.



Example of a calibration grid attached to the gripper of the robot

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. Laying out a plain sheet in the background is effective. Also, make sure to cover the printed text on the calibration grid.

1.2.3 Setting the Parameters

Use the [iRVision Utilities] page on the teach pendant to set the parameters.

On the teach pendant, press the [MENU] key, [iRVision], then [Vision Utilities], and press the [Enter] key.

The *i*RVision Utilities page appears.



2 Move the cursor to [Automatic Grid Frame Set] and press the [Enter] key. The [Grid Frame Set] page appears.



A CAUTION

The [Grid Frame Set] menu cannot be opened in more than one window at a time.

The following items are displayed on the [Grid Frame Set] page.

[Robot Group Number to Use]

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

[Set UFrame or UTool?]

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

[User Frame Number to set]

Specify the number of the user frame to be set. You can specify any number in the range between 1 and 9. This item is displayed only when [UFRAME] is selected for [Set UFrame or UTool?].

[Tool Frame Number to set]

Specify the tool frame number to be set. You can specify any number in the range between 1 and 10. This item is displayed only when [UTOOL] is selected for [Set UFrame or UTool?].

[Camera Name]

Specify the camera to be used for measurement. Move the cursor to [Camera Name] and press F4 [CHOICE] to display the list of cameras. Choose the camera to be used for measurement from the list.

[Exposure Time]

Specify the exposure time for the camera to capture an image. The greater the value, the brighter the image the camera can capture. 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 already been taught, [Recorded] is displayed, and if the position has not been taught, [Not Recorded] is displayed.

When [Not Recorded] is displayed, measurement cannot be executed. Be sure to teach the start position before starting measurement.

[Grid Spacing]

Set the grid spacing of the calibration grid in use.

[Setting Result]

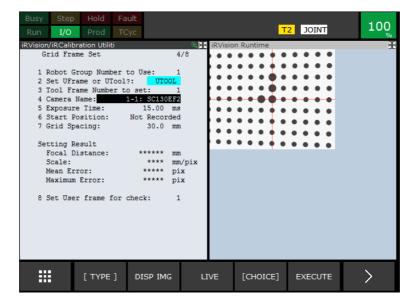
This item is displayed when the measurement is complete. For details, refer to "Setup: 7.1.4 Checking the Measurement Result" in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

[Check Tool/User Frame Setting]

This item can be set after the measurement is completed. It cannot be set when the measurement has not been completed. For details, refer to "Setup: 7.1.4 Checking the Measurement Result" in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

F2 [DISP IMG]

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



F3 [LIVE]

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

F4 [FIND]

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

F7 [DEFAULT]

The set values are initialized. [Camera Name] and [Start Position] will also be initialized and should be set again.

F8 [LED TYPE]

The setting screen for the LED light integrated in the camera package will be displayed. For details on LED lighting setup, refer to "Setup: 7.1.1.1 Setting the LED light" in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

F9 [MOVE_LIM]

The robot moves during the grid frame measurement process. The setting screen for limiting the amount of robot movement during such measurement is displayed. For details on the setting to limit the amount of robot movement, refer to "Setup: 7.1.1.2 Setting the move amount limit" in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

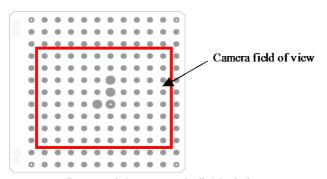
1.2.4 Teach the Start Position

Teach the initial position according to the following procedure.

- 1 If the Vision Runtime page is not displayed, press F2 [DISP IMG].
- 2 Move the cursor to [Start Position].
- Move the robot so that the camera's optical axis is approximately perpendicular to the plate surface of the calibration grid and that all four of the 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 a distance at which the grid comes into focus, which is, under normal circumstances, roughly the same as the distance at which camera calibration is performed.

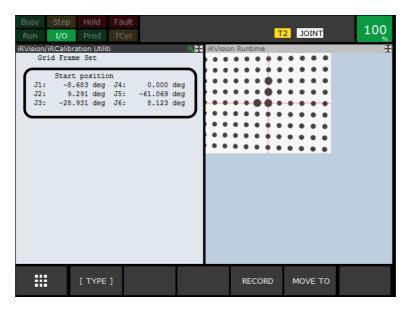
⚠ CAUTION

There is no need to include the entire grid pattern within an image to be captured. Some circles can extend beyond an image, but ensure that circles are distributed over an image.



Range of the camera's field of view

- While holding down the [SHIFT] key, press F4 [Record].
 The initial position is recorded, and the status of [Start Position] changes to [Recorded].
- 5 To check the value for the taught initial position, press F3 [Position]. The value for the initial position of each axis is displayed as follows.



To return to the previous page from this page, press the [PREV] key.

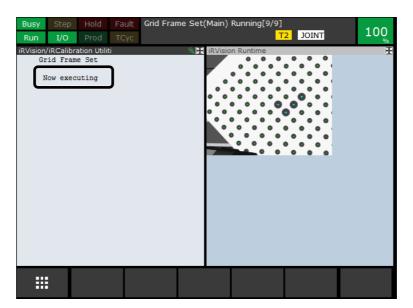
To move the robot to the taught initial position, press F5 [MOVE TO] while holding down the [SHIFT] key.

1.2.5 Run Measurement

Take the measurement according to the following procedure based on the taught initial position.

- 1 If the Vision Runtime page is not displayed, press F2 [DISP IMG].
- 2 Check the parameter settings on the [Grid Frame Set] page.
- 3 Check that the robot is in the initial position.
 - Hold the [SHIFT] key and press F5 [RUN].

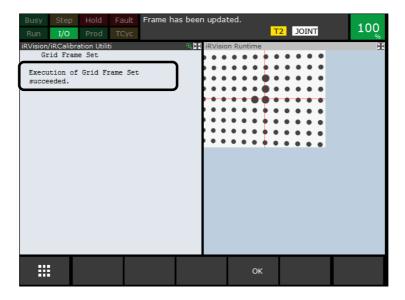
 The robot starts moving to execute measurement. The message 'Now executing' is displayed during operation.



↑ CAUTION

- 1 Releasing [SHIFT] while measurement is in progress stops the measurement. If that happens, perform the measurement again. You can resume the measurement from where it stopped.
- 2 During measurement, if you perform any operation that takes you to another menu, such as pressing SELECT, the measurement is stopped. If that happens, go to the [Grid Frame Set] menu again and perform the measurement again. You can resume the measurement from where it stopped.
- 3 The robot usually performs operations within an expected range according to the parameter setting. However, the robot can move beyond the expected range depending on the parameter settings. When running the Grid Frame Set, check that the related parameters are set correctly and decrease the override to 30% or less to ensure that the robot does not interfere with peripheral equipment.
- 4 If another program is paused, the robot may not be able to move. 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.



Press F4 [OK] to return to the grid frame setup screen.

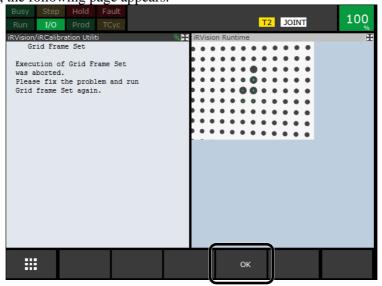
Checking Measurement

A grid frame is set via measurement. The set grid frame can be checked be performing the following procedure.

- Set the manual-feed coordinate system to the grid frame setting coordinate system. For a tool frame, press the [COORD] key, and change to [TOOL]. For a user frame, press the [COORD] key, change to [USER], and for [Tool] in the jog menu, specify the tool frame number specified for [Camera UTOOL] by using the number keys.
- 2 Press F3 [LIVE] to start live image display and jog the robot around the WPR of the selected tool frame. In the live image display, if the center position of the gird pattern is not far off the center line of the image, there is no problem.

If Measurement Fails

If measurement fails, the following page appears.



Press F4 [OK] to return to the previous page.

After changing the set parameters, press F5 [EXECUTE] while holding down the [SHIFT] key to perform the measurement again. If the grid frame setting process fails, refer to "Appendix: A TROUBLESHOOTING".

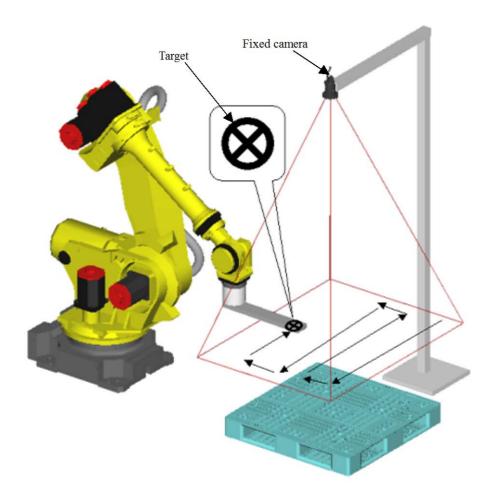
2 CAMERA CALIBRATION REFERENCE

This section describes robot-generated grid calibration, which is a camera calibration method.

2.1 ROBOT-GENERATED GRID CALIBRATION

Robot-generated grid calibration is a general-purpose camera calibration. The target mounted on the robot arm is moved within the camera's field of view to generate virtual grid patterns which calibrate the camera. Because a two-plane calibration is performed, it is possible to accurately determine the camera position and lens focal length. The robot moves to automatically measure the position where the target is mounted and the size of the camera's field of view.

Robot-generated grid calibration can be used for fixed cameras.



An example of a robot-generated grid calibration layout

Use the following steps to set up robot-generated grid calibration for 3D area sensors.

1. Selecting and Mounting Target
2. Creating a 3D Area Sensor Data
3. 3D Area Sensor Configuration
4. Calibration Setup
5. Train Model
6. Calibration
$\overline{\Box}$
7. Checking Calibration Point
$\overline{\Box}$
8. Checking Calibration Result

2.1.1 **Selecting and Mounting the Target**

Select the target to be used for calibration.

Target Shape

The target must satisfy the following conditions:

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

Examples of appropriate/inappropriate target shapes are shown below.







Examples of appropriate target shapes





The rotation angle cannot be identified.

The size cannot be identified.

Examples of inappropriate target shapes

Target Size

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

Mounting the Target

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



↑ CAUTION

Make sure that the target is securely fixed to the robot arm so that it does not move while the robot moves.

*M***EMO**

- 1 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 If positioning pins, etc. are used to mount the target in the same position every time, you can reuse the previously generated calibration robot program when recalibrating.

2.1.2 Creating a 3D Area Sensor Data

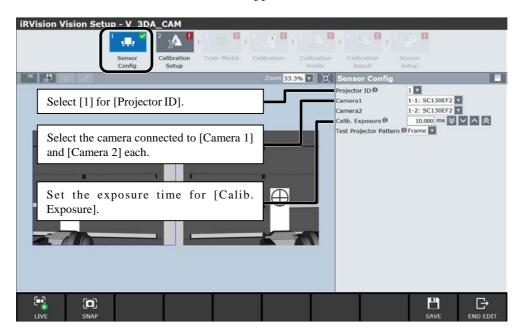
Create 3D area sensor data and perform required settings.

For details, refer to "Basic Setup Procedures: 1.3 SETTING UP 3D AREA SENSOR DATA" and "Basic Setup Procedures: 2.3 SETTING UP 3D AREA SENSOR DATA".

2.1.3 3D Area Sensor Configuration

Configure camera calibration and other settings for setting up 3D area sensor. This section uses the 3D area sensor data created in "Basic Setup Procedures: 1.3 SETTING UP 3D AREA SENSOR DATA" as an example for explanation.

Click the created 3D area sensor data on the vision data list screen, and click [Sensor Config] in the navigation area. A screen similar to the one below appears.

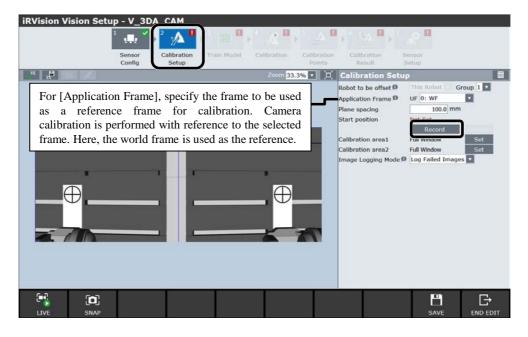


2.1.4 Calibration Setup

Set up calibration for two 3D area sensor cameras.

In the navigation area of the edit screen for the 3D area sensor data, click [Calibration Setup]. A screen similar to the one below appears.

In the simple mode, an application frame is set to the world frame. If you want to set an application frame to another user frame, switch the mode to the advanced mode, which allows you to set any user frame and set the plane spacing and initial position.



[Application Frame]

Select the frame used as a reference for camera calibration.

In robot-generated grid calibration, calibration is performed by moving the robot parallel to the XY plane of the reference frame. Make sure that the optical axis of the 3D Area Sensor projector is almost parallel with the Z-axis of the application frame. If the Z-axis of the world frame is not parallel to the optical axis of the projector due to the installation of the 3D Area Sensor, set an additional user frame and select it as the reference frame.



⚠ CAUTION

When specifying a user frame as the application frame, set the user frame prior to camera calibration. If you change the user frame setting after performing camera calibration, you will need to redo the calibration.

[Plane spacing]

Enter the spacing for the 1st and 2nd calibration planes in the text box. The optimal plane spacing is approximately 10% of the distance between the camera and the 1st plane.

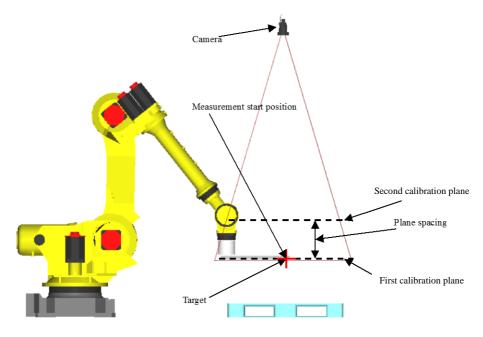
If the Z-axis of the application frame is directed toward the camera, setting a positive value will cause the 2nd plane to be located closer to the camera than the 1st plane, which reduces the risk of the robot interfering with peripheral equipment while in operation.

If the Z-axis of the application frame is directed away from the camera, setting a negative value will cause the 2nd plane to be located closer to the camera than the 1st plane.

[Initial position]

Specify the measurement start position. This start position should be set so that the target mounted on the robot end of arm tooling comes roughly at the center of the camera's field of view. Jog the robot to an appropriate position as the measurement start position and click the [Record] at that position to record the measurement start position.

The height of the start position is equal to that of calibration plane 1. During camera calibration, the robot moves parallel to the XY plane of the application frame, while maintaining the posture of the start position.



Initial position

MEMO MEMO

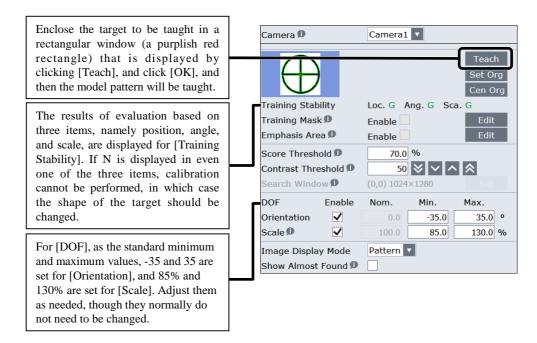
If there is a problem such as the robot interfering with peripheral equipment, you can narrow the range of the robot operation during calibration and the range of finding the target by changing the settings for [Calibration area 1] and [Calibration area 2]. For details, refer to "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.1.5 Train Model

Teach the model pattern for target detection.

In the navigation area of the edit screen for 3D area sensor data, click [Train Model]. A screen similar to the one below is displayed. Teach the shape of the target to be used for calibration as the model pattern for the GPM Locator Tool. After moving the robot to the recorded initial position, teach the model.

In the simple mode, items for which settings are frequently changed are displayed. When you switch to the advanced mode, all the setting items are displayed. For details, refer to the description of GPM Locator in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".



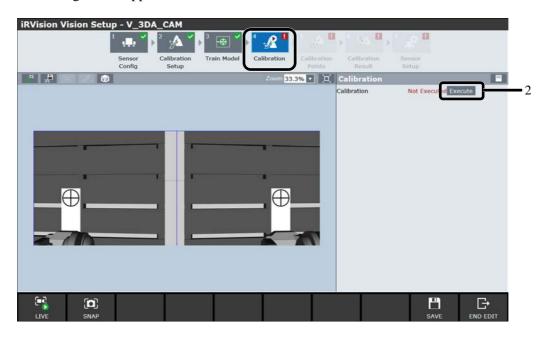
*M***EMO**

Set up the size of the rectangular window to be slightly larger than the target. The position of the robot is controlled during measurement so that the area of the rectangle window taught here is confined within the search window. So the larger the trained rectangle is, the smaller the target mark displacement range is, therefore more likely to decrease the accuracy of the camera calibration.

2.1.6 Calibration

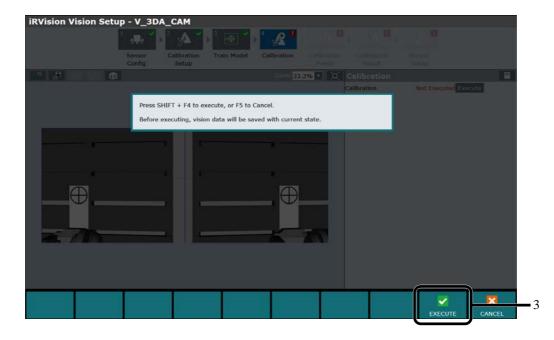
Calibrate the cameras.

1 In the navigation area, click [Calibration]. The following screen appears.



- 2 Click the [Execute] button in [Calibration].
- When the following confirmation screen appears, click [EXECUTE] while holding down the [SHIFT] key on the teach pendant.

Camera data before executing calibration is saved and then calibration is executed.



⚠ CAUTION

- 1 Calibration can only be executed on the teach pendant. This action cannot be performed on the PC.
- 2 Calibration is terminated when you release the [SHIFT] key while calibration is being executed. In such cases, redo the calibration.
- 3 The robot usually performs operations within an expected range according to the parameter setting. However, the robot can move beyond the expected range depending on the parameter settings. When executing the calibration, 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.
- 4 If another program is paused, the robot may not be able to move. In such cases, press the [FCTN] key and end the programs.
- 5 When redoing a calibration that was suspended in the middle of execution, you can start from the part where it ended the last time.

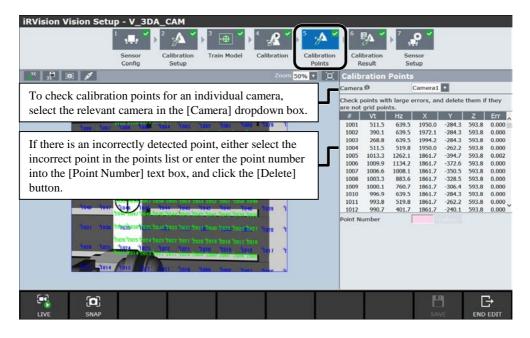
MEMO

By switching to the advanced mode, you can change the target position setting from automatic measurement to direct specification. For details, refer to "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

2.1.7 Checking Calibration Point

Check the identified calibration points.

In the navigation area of the edit screen for the 3D area sensor data, click [Calibration Points]. A screen similar to the one below appears.



At the center of each dot found in the image, the calibration point on the 1st plane and that on the 2nd plane are respectively shown as a blue and a green "+". In addition, each calibration number is displayed at the lower right of the "+". A red "+" indicates the 3D position of each dot projected in the image using the calculated calibration data. Since blue and green "+" are plotted after red "+", "+" will not be shown in red if their positions match.

In the item setup area, the following information on the calibration points is displayed.

[Camera]

Select the camera for which you want to check the calibration points from the drop-down box.

[Vt], [Hz]

The coordinate values of the found calibration points in the image.

[X], [Y], [Z]

The coordinate values of the grid to be offset on the user frame.

[Err]

The distance between the center of each green or blue "+" and the center of each red "+" plotted in the image. The smaller this value, the more accurate the calibration. The unit is in pixels (pix).

Deleting a calibration point

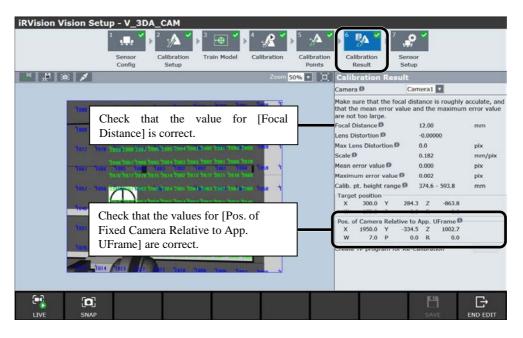
When "+" in green appears at a point other than a grid point, delete the relevant calibration point according to the following procedure.

- 1 Enter the index number of the calibration point that you want to delete in the text box on the left of the [Delete] button.
- Click the [Delete] button.The specified point is deleted from the list and calibration data is recalculated.

2.1.8 Checking Calibration Result

Check the calculated calibration data.

In the navigation area of the edit screen for the 3D area sensor data, click [Calibration Result]. A screen similar to the one below is displayed.



In the item setup area, the following information on the calibration result is displayed.

[Camera]

Select the camera for which you want to check the calibration result from the drop-down box.

[Focal Distance]

The calculated focal distance of the lens is displayed.

Check if the value is appropriate for the lens in use. The nominal focal distance is labeled on the lens.

[Lens Distortion]

The calculated lens distortion coefficient is displayed.

A larger absolute value indicates greater lens distortion.

Generally, lenses with shorter focal distances are said to have greater distortion. In robot-generated grid calibration, the [Lens Distortion] measured here to accurately convert the image frame to the robot frame.

[Max Lens Distortion]

Expresses in pixels (pix) the size of the distortion at the location where the lens distortion is greatest.

[Scale]

The ratio of a millimeter (mm) to a pixel (pix) on the 1st plane.

The value indicates how many millimeters are equivalent to a pixel.

The scale value is approximate since the scale is not even throughout the entire image.

[Mean error value], [Maximum error value]

The average and maximum values of all the calibration points.

[Calib. pt. height range]

The range of Z height of the calibration points that have been found on the application frame.

[Target position]

The target position in the mechanical interface frame that has been measured during calibration.

[Pos. of Camera Relative to App. UFrame]

The position of the camera in the application frame is displayed.

[Create TP program for Re-Calibration]

Press the [Create] button to create a TP program for recalibration.

After clicking the [Create] button, specify the name of the TP program to be created.



A program for recalibration can only be created immediately after calibration has completed. If the camera data is closed then, the program can no longer be created. In such cases, redo the calibration and then create a program.

For details about [Sensor Setup], refer to "Basic Setup Procedures: 1.3.8 3D Area Sensor Setup".

2.1.9 Automatic Recalibration

If the camera is misaligned or it has been replaced after starting the system for any reason, recalibration of the camera is needed. If this is the case, use automatic recalibration to easily restore the calibration. Since automatic recalibration restores the calibration without manual operation, mistakes in the calibration operation can be prevented.

In robot-generated grid calibration, a recalibration program can be created using [Create TP program for Recalibration] on the [Calibration Result] screen, and recalibration is performed by executing that program from the beginning.

For details, refer to "Setup: 2.2.3.7 Automatic re-calibration" in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

⚠ CAUTION

In automatic recalibration, the target mount position will not be set again. Make sure that the target is firmly fixed to the position at which calibration was initially performed and will not move.

3D AREA SENSOR REFERENCE

3D AREA SENSOR GUIDANCE

3D Area Sensors are 3D sensors consisting of two camera units and one projector unit. The 3D Area Sensor obtains 3D information in the field of view by using the two camera units to capture multiple stripe pattern images as projected by the projector unit. It can obtain the 3D positions of multiple points in grid patterns from the area in the field of view all at once. Each acquired point is referred to as a 3D point, and the entire set of the 3D points acquired each time is referred to as a 3D map.

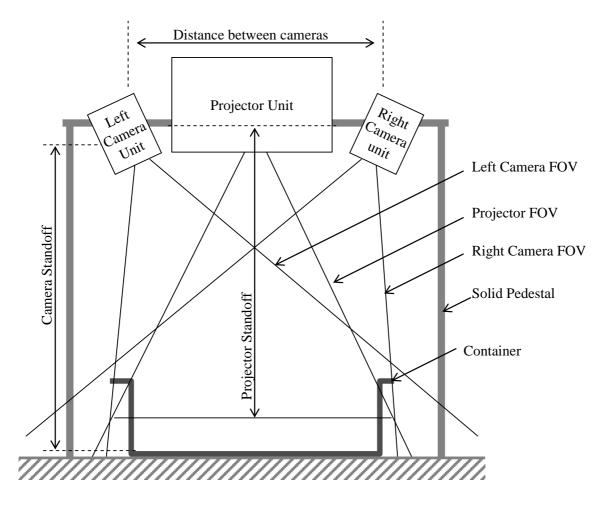
The camera units and the projector unit of 3D Area Sensor should be mounted on a solid mounting structure. Each unit of 3D Area Sensor needs to be securely mounted above the target container.

⚠ CAUTION

The 3D Area Sensor cannot be mounted on a robot.

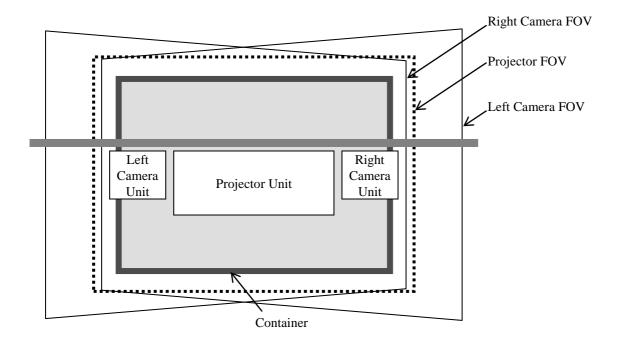
3.1.1 **Standard Layout**

The figure below shows a standard layout for the camera units and the projector unit as seen from the front. Fix the camera units and the projector unit to the same beam.



Standard layout example for 3D Area Sensors (front)

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



Standard layout example for 3D Area Sensors (overhead)

As seen from above, the camera units and the projector unit are placed in the same straight line. When the camera standoff distance is fixed, as the distance between the two cameras is increased, the Z height accuracy is improved but the blind spot increases. If the cameras are placed outside the container sidewall, the measured target cannot be seen because of the wall, so place the camera units on the upper part inside the wall.

The Z height accuracy (theoretical value) can be estimated roughly by using the following formula based on the distance between the cameras and the camera standoff distance.

⚠ CAUTION

The Z height accuracy calculated from the above formula is a theoretical value. The actual Z height accuracy is affected by various factors such as the focus of projected pattern, camera focus, ambient light, accuracy of each camera calibration, etc.

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



⚠ CAUTION

Depending on the size of container and the required Z accuracy, there is a case that mounting the camera units and the projector unit at different heights is preferable.

3.1.2 Camera Calibration

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

3.1.3 Projection FOV and Standoff of Projector Unit

The projection FOV of the projector unit should cover the entire container with the height of the container upper part.

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

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

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

3.1.4 FOV of Cameras

As with the projection FOV of the projector unit, the FOV of the camera units should cover the entire container. The FOV of the camera units affects the detection capability of the patterns projected by the projector unit. For example, if the FOV of the camera units is too wide in comparison with the projection FOV of the projector unit, it is difficult to acquire 3D points accurately because fine patterns would not be clear enough in the image. Whenever possible, place the camera units and the projector unit so the FOV of the camera units matches the projection FOV of the projector unit. In addition, adjust the direction of the camera units so that the optical axis of the camera units roughly passes through the center point of the container.

3.1.5 Ambient Lights

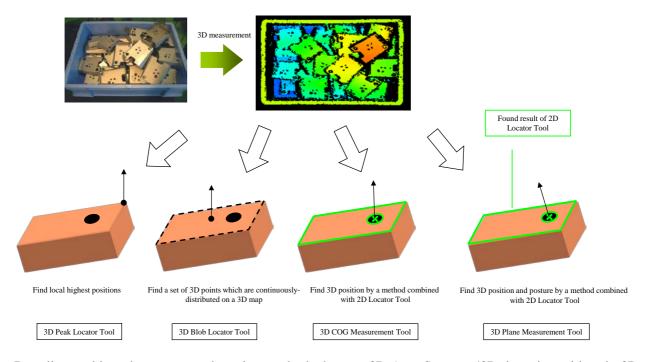
Ambient lights can affect the robustness of 3D Area Sensor. The stronger the ambient lights are, the less stable the measurement results of 3D Area Sensor can be. If the intensity of ambient lights is too strong, shade the container from the ambient lights.



The lighting for 2D detection should be turned off while acquiring 3D Area Sensor.

3.2 GENERAL DESCRIPTION OF 3D AREA SENSOR FRATURES

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



Broadly speaking, there are two detection methods that use 3D Area Sensors: '3D detection with only 3D map' and '3D detection with combination of the 2D Locator Tool'. Note that the 2D Locator Tool finds on images captured by cameras the same patterns that were taught on 2D images in advance. In this manual, the 2D Locator Tool refers to the GPM Locator Tool and the CSM Locator Tool.

3.2.1 3D Detection with Only 3D Map

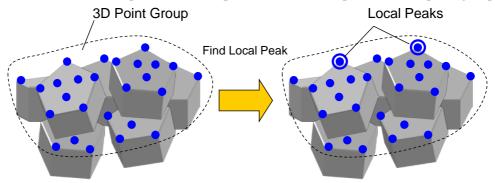
Parts are found only using 3D maps without images captured by cameras. If the orientation of a part changes 3-dimensionally, then how the part is represented on the 2D image changes greatly. The '3D Detection with Only 3D Map' is characterized by the ability to find parts stably without being affected by the change in orientation. There are the following five types of '3D Detection with Only 3D Map'.

- 3D peak locator tool
- 3D Blob Locator tool
- One-Sight-Model Locator Tool
- 3D Cylinder Locator tool
- 3D Gripper Finger Locator tool

There is also the 3D Data Preprocess Tool, which removes the 3D points causing false detection and 3D points not needed for detection from the 3D map before detection by the above command tools.

3.2.1.1 3D Peak Locator Tool

The 3D Peak Locator Tool finds positions of 3D points that are local peaks in a 3D point group.



Detection by the 3D Peak Locator Tool

The 3D Peak Locator Tool performs a simple detection function to find locally high places from the piles of parts in bulk within the container, so it can find almost all of the parts if their 3D point group can be acquired. However, because the detected position on a part is always different every time this tool detects, this tool is valid for those types of parts that can be suctioned by vacuum grippers regardless of the approaching direction. For example, the following parts are suitable for this tool.

- Spherical part
- Cylindrical part

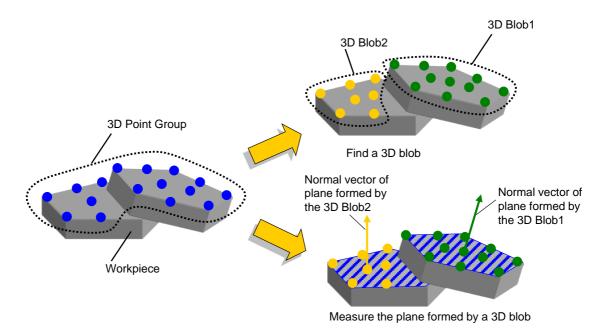
For details, refer to the description for the 3D Peak Locator Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

Precautions

- The 3D Peak Locator Tool does not measure the orientations of parts. The orientation data acquired by the 3D Peak Locator Tool correspond to the orientations selected for [Offset Frame] in the 3D Area Sensor vision process. Therefore, the W, P and R values of found positions are always 0.
- Found local peaks are not always located at a specific pretrained position on the parts because this function finds the highest positions of the part from the 3D map.
- For the above reason, this tool is not suitable for grippers that require both the position and orientation data to grip parts. To pick up parts in bulk by using the 3D Peak Locator Tool, use a vacuum or magnetic gripper that can pick up parts by using only the rough position information of parts.

3.2.1.2 3D Blob Locator Tool

The 3D Blob Detection Tool finds a set of connected points that are neighborhood points in a 3D point group. If a set of connected points form a plane, it can also measure the plane.



Detection by the 3D Blob Locator Tool

The 3D Blob Locator Tool is valid for parts with a smooth and wide surface because it finds sets of connected 3D points that are neighborhood points in the 3D point group. For example, the following parts are suitable for this tool.

• Plate part

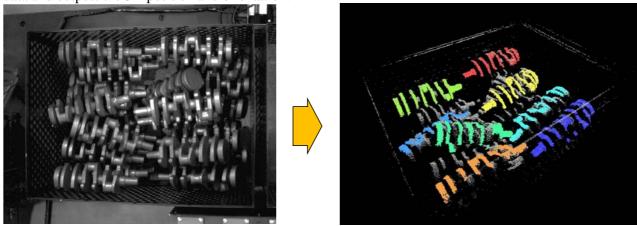
For details, refer to the description for the 3D Blob Locator Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

Precautions

- If the 3D Blob Locator Tool is set up not to measure planes, the acquired +Z direction value of the orientation is always identical to the +Z direction value of [Offset Frame] selected in the 3D Area Sensor vision process. Therefore, the W and P values of found positions are always 0.
- Since acquired 3D points vary depending on the orientations and piles of parts, the found positions are not always output as the same positions on the parts.
- For the above reason, this tool is not suitable for grippers that require both accurate position the position and orientation data to grip parts. To pick up parts in bulk by using the 3D Blob Locator Tool, use a vacuum or magnetic gripper that can pick up parts by using only the rough position information of parts.

3.2.1.3 3D One-Sight-Model Locator Tool

The '3D One-Sight-Model Loc. Tool' detects a 3D model pre-taught to the one sight of a part from 3D data and outputs the 3D position and orientation.



With the '3D One-Sight-Model Loc. Tool', a 3D model is taught, but it also allows a model to be taught from a 3D model acquired from the sensor and CAD data (STL file) to be used as a model.

In 3D one-sight-model detection, complex characteristics of 3D points are detected as a 3D model and therefore found positions cannot stably obtained for planar parts. It is effective for parts in a stepped shape or in a complex 3D shape with multiple curved shapes.

For details, refer to the description for the 3D One-Sight-Model Loc. Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

Precautions

- Parts in bulk may take a wider range of orientations. In response to such cases, use multiple 3D one-sight model locator tools to teach a 3D model from multiple orientations, such as front and rear, so that parts in various orientations can be matched with the 3D model.
- When using a CAD data file as a 3D model, make sure that the file size is 10 MB or less. A larger file size will take extremely long time for processing.

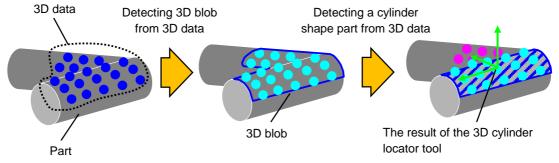
3.2.1.4 3D Cylinder Locator Tool

The '3D Cylinder Loc. Tool' is used to detect cylinder shape parts from 3D data.

The 3D Cylinder Loc. detects cylindrical parts in the following two steps.

- 1 Detect 3D blob from 3D data.
- 2 Detect a cylinder shape part from the detected 3D blob.

For details, refer to the description of the 3D Cylinder Loc. Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".



Detecting a cylinder shape part

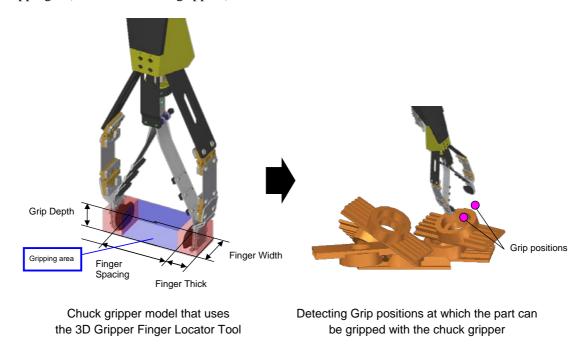
Precautions

• The 3D cylinder detection function is used to detect a cylinder with the specified diameter and length.

If the part is not cylinder shape, use the 3D One-Sight-Model Loc. Tool.

3.2.1.5 3D Gripper Finger Locator Tool

The 3D Gripper Finger Locator tool is effective in performing bin picking using a gripper that grips a part by clipping it (hereafter, "chuck gripper").



Example use of 3D gripping position detection tool

The 3D Gripper Finger Locator tool detects and outputs a position that it can easily grip the part based on the set chuck gripper model and 3D data. For details, refer to the description of the 3D gripping position tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

This tool is effective for parts in bulk where spaces for easily gripping them with a chuck gripper are likely to present.

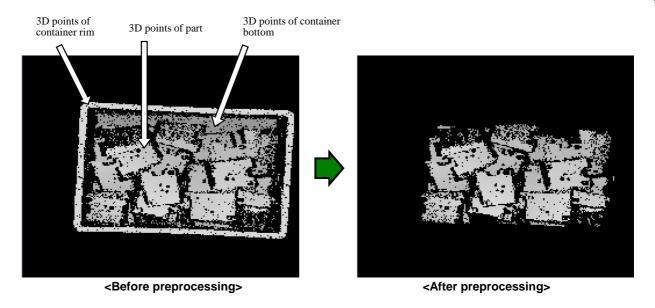
It detects a location at which the chuck gripper can grip the part rather than the model of the part, teaching for each part is not necessary once parameters have been set.

Precautions

• The acquired +Z direction value output from the 3D gripping position detection function is always identical to the +Z direction value of [Offset Frame] selected in the 3D Area Sensor vision process. Therefore, the W and P values of found positions are always 0.

3.2.1.6 3D Data Preprocess Tool

3D detection tools using only a 3D map basically use all the 3D points included in the 3D point group for processing. Therefore, incorrect detection is caused by the inclusion of a set of 3D points that may include the following unneeded 3D points: 3D points acquired from an area other than a part such as the bottom of the container, and 3D points judged as outlier 3D points. Before processing with these tools, remove unneeded 3D points. This is done by the 3D Data Preprocess Tool.



Result after removing unnecessary 3D points by the 3D Data Preprocess Tool

Also, if the container position changes for each container replacement, the data corresponding to the container can be removed from the 3D point group by using the 3D Data Preprocess Tool together with the Window Shift Tool. For details, refer to the description for the 3D Data Preprocess Tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

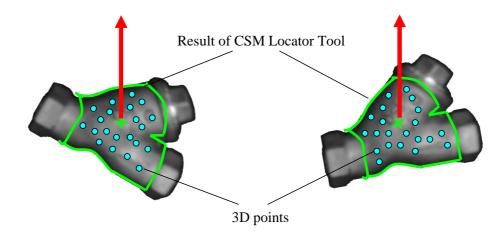
3.2.2 3D Detection with Combination of 2D Locator Tool and 3D Map

3D detection is performed with a combination of 2D model detection. It is necessary to use 2D Locator Tool for parts, but since they find a predetermined location on a part for the found position or the found position and orientation, it is possible to grip parts by using those types of grippers that grip a given location on parts such as the chuck. There are following four types of tools for performing 3D detection with a combination of 2D model detection.

- 3D COG Measurement tool
- 3D Plane Measurement tool
- 3D Obstruction Measurement tool
- 3D Box Locator Tool

3.2.2.1 3D COG measurement tool

The 3D COG Measurement Tool computes the center of gravity of the 3D point group in the measurement area. Combining the result of this tool with a result of 2D locator tool makes it possible to measure the 3D position of a part. For details, refer to the description for the 3D COG Measurement Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".



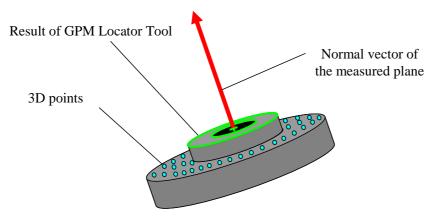
Detection by the 3D COG Measurement Tool

Precautions

- First, the detection by the 2D Locator Tool must be successful. If parts look very different depending on their orientation, teach several model patterns.
- If the 3D COG Measurement Tool is used to acquire the position and orientation of parts, the acquired +Z direction value of the orientation is always identical to the +Z direction value of [Offset Frame] selected in the 3D area sensor vision process. Therefore, the W and P values of found positions are always 0.

3.2.2.2 3D plane measurement tool

The 3D Plane Measurement Tool measures a plane from the 3D points in the measurement area. Combining the result of this tool with the result of the 2D locator tool makes it possible to measure the 3D position and orientation of a part. It is also possible to compute the 3D position and orientation of parts even if the location where the features included in the 2D model exist is not on the same plane as the location for which the plane is measured. For details, refer to the description for the 3D Plane Measurement Tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".



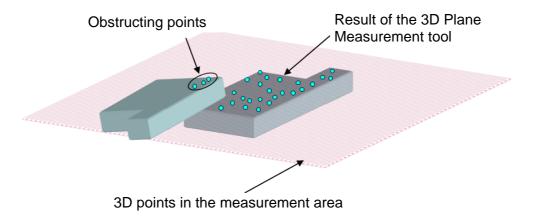
Detection by the 3D Plane Measurement Tool

Precautions

• First, the detection by the 2D Locator Tool must be successful. If parts look very different depending on their orientation, teach several model patterns.

3.2.2.3 3D Obstruction Measurement Tool

The 3D Obstruction Measurement tool measures overlapping points and the overlap ratio. 3D points obtained above the resulting plane specified by 3D points in the measurement area with a 3D Plane Measurement tool are measured as overlapping points. The overlap ratio is the ratio of the number of 3D points in the measurement area to the number of overlapping points.



Measuring overlapping points and overlap ratio using 3D points

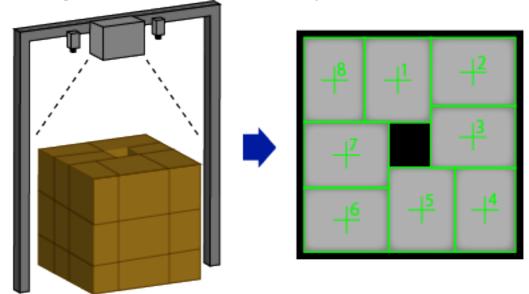
The 3D Obstruction Measurement tool can only be used if the following conditions are satisfied.

- Placed as a child tool of the GPM Locator Tool and the CSM Locator Tool.
- The 3D Plane Measurement tool is in the same level as the 3D Obstruction Measurement tool and has been placed prior to the 3D Obstruction Measurement tool.

For details, refer to the description for the 3D Obstruction Measurement tool in "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

3.2.2.4 3D Box Locator Tool

The 3D Box Locator tool is effective in detecting palletized boxes, etc. It finds a part by detecting the top of a box with the specified size with 3D data and camera images.

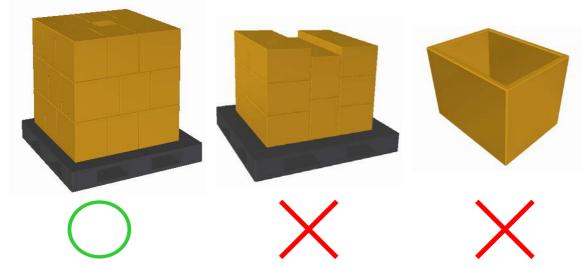


Detecting palletized boxes, etc. with 3D data and camera images and outputting 3D positions and orientations

For details, refer to the description of the 3D box locator tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

Precautions

- The following conditions need to be met to correctly find parts:
 - Parts are cuboids of the same size.
 - The same surface faces the sensor.
 - The surface facing the sensor is a plane (The tool cannot be applied to a part such as an open top box as shown in the following figure).



Example of parts that can be found with the 3D Box Locator Tool

3.3 UNMEASURABLE PARTS

3D Area sensor obtains 3D maps by using projected pattern light. Therefore, if the pattern light cannot be captured with the 2 camera units, obtaining a 3D map is difficult. For example, the following parts are suitable for this tool.

- Transparent
- Reflective
- Thin wire

3.4 SETUP PROCEDURES OF 3D AREA SENSOR

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

- Adjusting the layout of 3D Area Sensor
- Adjusting the focus of the projector unit
- Adjusting the focus of the camera unit
- Adjusting the conditions for acquiring a 3D Map

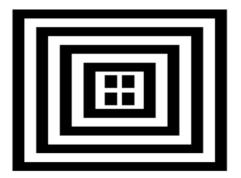
3.4.1 Adjusting the Layout of 3D Area Sensor

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

Projection of Test Projector Pattern

Project the test projector pattern to adjust the position of the projector unit.

- 1 Display the edit screen for the 3D area sensor data, and click [Sensor Config].
- 2 Select [Frame] from the [Test Projector Pattern] drop-down box and click [PRJ ON] to project the frame pattern to the container where parts are placed. The following pattern is projected.



Projected frame pattern

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

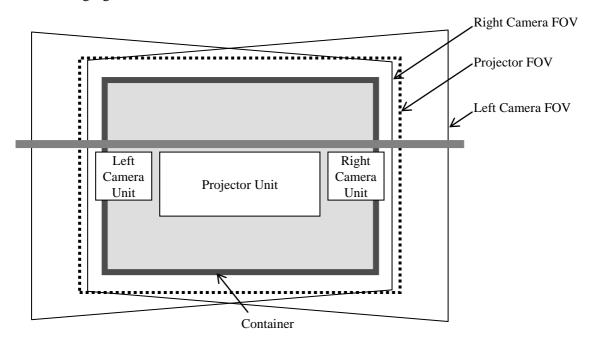


Example where the frame pattern is projected to the entire container

Adjustment of Camera Unit Position

Next, adjust the camera unit position.

The camera units and the projector unit are placed in the same straight line. When the camera standoff distance is fixed, as the distance between the two cameras is increased, the Z height accuracy is improved but the blind spot increases. If the cameras are placed outside the container sidewall, the measured target cannot be seen because of the wall, so place the camera units on the upper part inside the wall as shown in the following figure.



Standard layout example for 3D Area Sensors (overhead)

Adjustment of Camera Unit Angle

Next, adjust the camera unit angle.

- 1 Display the edit screen for the 3D area sensor data, and click [Sensor Config].
- 2 Select [Frame] from the [Test Projector Pattern] drop-down box.
- 3 Click [SNAP]. Images from two cameras appear in the image view area. Adjust the position and direction of the camera units so that the center of the pattern is located around the center of the image and the entire container fits in the view.

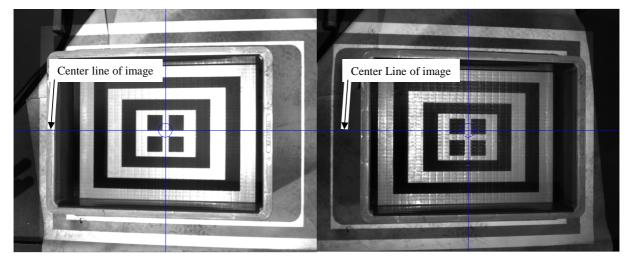


Image of Camera View1

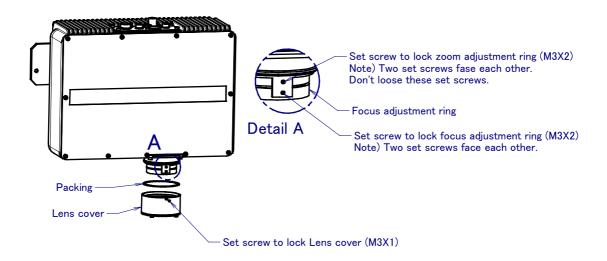
Image of Camera View2

↑ CAUTION

When the container is displayed fully on the image, place a flat plate on the top of the container and adjust so that the center of the pattern is located around the center of the image.

3.4.2 Adjusting the Focus of the Projector Unit

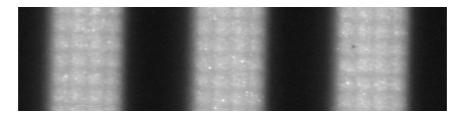
This subsection explains the procedures for adjusting the focus of the projector unit. Adjust the focus of the projector unit according to the following procedure.



Hardware configuration example for the projector unit

- Place something with a flat plane at the middle height of the range where measurement is to be conducted with the 3D Area Sensors.
- 2 Loosen the M3 set screw that fixes the lens cover.
- 3 Turn the lens cover counterclockwise and remove the lens cover and packing.
- 4 Loosen two M3 set screws (at both faces) that fix the focus adjustment ring. Be careful not to loosen the M3 set screws that fix the zoom adjustment ring.
- 5 Open the edit screen for the 3D area sensor data.

- 6 Select [Stripe] from the [Test Projector Pattern] drop-down box and click [PRJ ON]. The stripe pattern is projected by the projector unit.
- While observing the projected pattern, turn the focus adjustment ring to adjust the focus. If the projector is in focus, you can see fine grid patterns from the projection device (DMD) (as shown in the figure below).

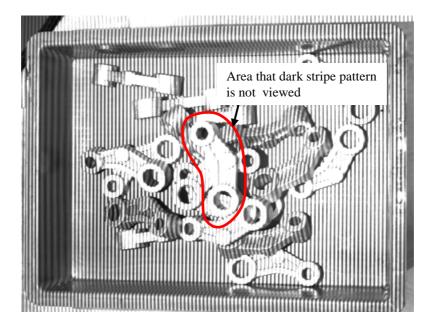


8 Tighten two Set Screws that lock Focus Adjustment Ring, and fix Focus Adjustment Ring. Caution: If one of two Set Screws is tightening too much at a time, excessive pressure would be applied to the projection lens. So be sure to screw them by bits alternately.

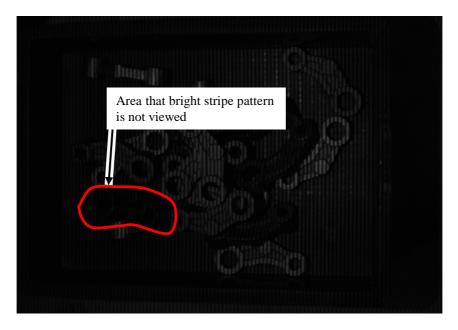
3.4.3 Adjusting the Focus of the Camera Unit

This subsection explains the procedures for adjusting the focus of the camera unit. Adjust the focus of the camera unit according to the following procedure.

- 1 Remove the cover of the camera unit.
- Display the edit screen for the 3D area sensor data, click [Sensor Setup] in the navigation area, and select [11] from the [Intensity] drop-down box.
- In the navigation area of the edit screen for the 3D area sensor data, click [Sensor Config] and enter 10.0 in the [Calib. Exposure] text box. The unit is milliseconds.
- 4 Loosen the set screw for the aperture.
- While observing the images from the two cameras that appear in the image view area, adjust the lens aperture for each camera.
- 6 Select [Stripe] from the [Test Projector Pattern] drop-down box and click [SNAP].
- If there is an area where black stripes of the projected pattern cannot be seen because of halation, close the lens aperture.

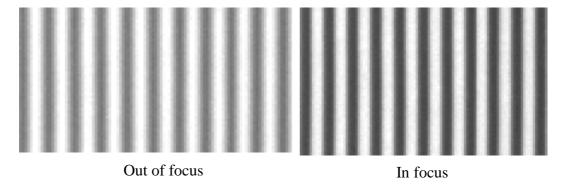


If there is an area where the bright stripe cannot be viewed, then open the lens aperture.



- 8 Perform Step 5 while changing the part packing states to determine the lens aperture.
- 9 Tighten the set screw and turn it until the tip hits the edge of the lens.
 After the tip of the set screw hits the lens side, further turn it 3/8 (135 degrees).
- 10 Loosen the set screw for the focus.
- While observing the images from the two cameras that appear in the image view area, adjust the lens focus for each camera.
- 12 Place something with a flat plane at the middle height of the range where measurement is to be conducted with the 3D Area Sensors.
- 13 Select [Stripe] from the [Test Projector Pattern] drop-down box and click [SNAP].

 Adjust the lens focus so that the boundaries between white stripes and black stripes can be identified clearly as shown in the figure below.



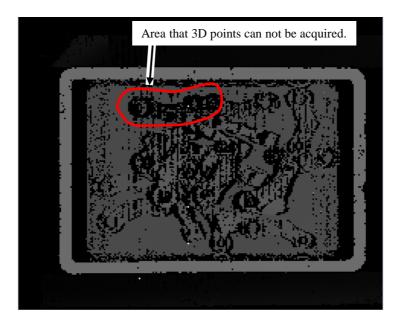
14 Tighten the set screw and turn it until the tip hits the edge of the lens. After tip of set screw hits the lens side, rotate it 3/8 (135 degree).

3.4.4 Adjusting the Conditions for Acquiring a 3D Map

This subsection explains the procedures for adjusting the conditions for acquiring a 3D map when there is an area where 3D points are not acquired. The condition should be adjusted in the following three steps.

3.4.4.1 Confirming the condition of the area where 3D points are not acquired

- 1 Display the edit screen for the 3D area sensor data, and click [7 Sensor Setup] in the navigation area.
- 2 Click [ACQ 3DMAP] to acquire the 3D map.
- 3 Check the area where 3D points cannot be acquired.



In the navigation area of the edit screen for the 3D area sensor data, click [Sensor Config] and check the stripe pattern status of the area where 3D points could not be acquired in the images from the two cameras that appear in the image view area.

In the figure below, there is an area where black stripes of the projected pattern cannot be seen because of halation, which means that the 3D points could not be acquired in that area.

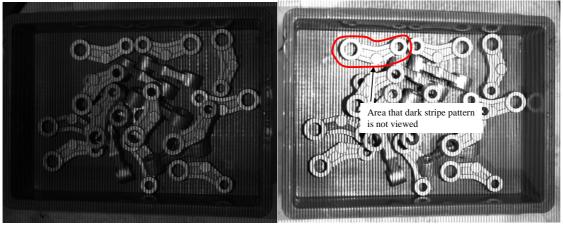


Image of Camera View1

Image of Camera View2

3.4.4.2 Adjusting the exposure time

In cases where 3D points cannot be acquired, reduce the exposure time if it is too bright and extend the exposure time if it is too dark. Here, set up the exposure time so that the brightness of the entire view does not change while in camera live mode according to the following steps.

- 1 Display the edit screen for the 3D area sensor data, and click [Sensor Config] in the navigation area.
- 2 Select [Black] from the [Test Projector Pattern] drop-down box and click [SNAP].
- 3 Make sure that the brightness of the entire view does not change in the images from the two cameras that appear in the image view area.

3.4.4.3 Adjusting the intensity

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

- 1 Display the edit screen for the 3D area sensor data, and click [7 Sensor Setup] in the navigation area.
- 2 Change the value for [Intensity].
 - If 3D points cannot be acquired because of the brightness, set [Intensity] to a value that is smaller than the current value.
 - If 3D points cannot be acquired because of the darkness, set [Intensity] to a value that is larger than the current value.
- 3 Click [ACQ 3DMAP] to acquire the 3D map.
- 4 Check the area where 3D points cannot be acquired. If there is an area where 3D points cannot be acquired, proceed to Step 5.
- In the navigation area of the edit screen for the 3D area sensor data, click [Sensor Config], select [Stripe] from the [Test Projector Pattern] drop-down box, and click [SNAP].
- 6 Check the stripe pattern status of the area where 3D points could not be acquired in the images from the two cameras that appear in the image view area, and proceed to Step 2.
- If adjusting the [Intensity] value does not solve the issue of the area where 3D points cannot be acquired, adjust the exposure time again.

If 3D points cannot be acquired by making the adjustments described in this section, try the adjustments described in "References: 3.4.2 Adjusting the Focus of the Projector Unit" and "References: 3.4.3 Adjusting the Focus of the Camera Unit" again.

∕МЕМО

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

3.5 MACRO PROGRAMS

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

BINPICK ACQUIRE3DMAP

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

Argument 1:

Specify the vision data name of the 3D Area Sensor

BINPICK_ACQUIRE3DMAP is the following macro program.

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

The function and the arguments of the macro program can be viewed by opening the macro program.

BINPICK_CLEAR3DMAP

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

Argument 1:

Specify the vision data name of the 3D Area Sensor

BINPICK_CELAR3DMAP is the following macro program.

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

The function and the arguments of the macro program can be viewed by opening the macro program.

4 INTERFERENCE AVOIDANCE REFERENCE

4.1 BASIC OPERATION FOR INTERFERENCE SETUP

This section explains the basic operation for the setup of data for the interference avoidance function. The bin picking software has the pre-installed sample interference avoidance data, allowing the system to be set up quickly. Add or delete data as necessary according to each actual application.

MEMO

The number of data items that can be registered with the interference avoidance function is limited. However, the maximum number of data items that can be registered can be changed on the interference avoidance configuration screen on the teach pendant. For details, refer to "Advanced Setup: 1.1 INTERFERENCE AVOIDANCE CONFIGURATION".

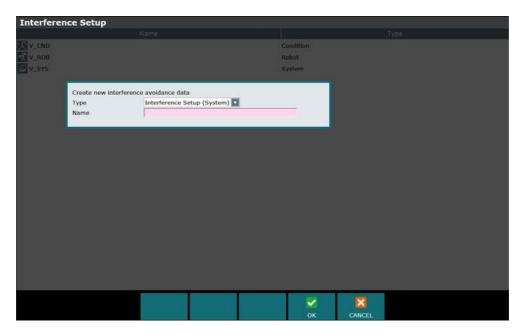
4.1.1 Operation for Interference Setup Data

To operate interference avoidance data, select $[iRVision] \rightarrow [Interference Avoidance Setup]$ in the robot home page.

4.1.1.1 Creating new data

Use the following procedures to create interference avoidance data.

1 Click [CREATE] on the interference avoidance data list screen and a pop-up window appears for creating new interference avoidance data.



- 2 Select the type of interference avoidance data to create from the [Type] drop-down box.
- 3 Enter the name of the interference avoidance data in [Name].
- 4 Click [OK].

The interference avoidance data is newly created.

Click [CANCEL] to cancel creating new data.

4.1.1.2 Editing

Use the following procedures to open the edit screen for interference avoidance data.

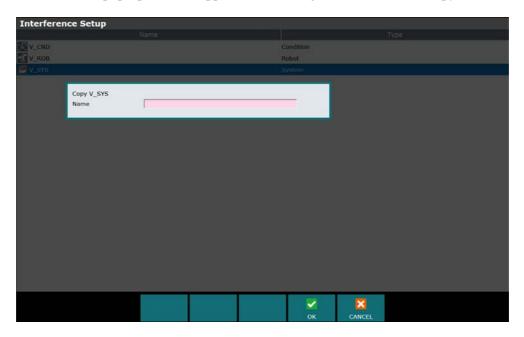
- 1 On the interference avoidance data list screen, select the interference avoidance data to set.
- 2 Click [EDIT].

 The interference avoidance data edit screen appears.

4.1.1.3 Copying

Use the following procedures to copy interference avoidance data.

- 1 On the interference avoidance data list screen, select the interference avoidance data to copy.
- 2 Click [COPY] and a pop-up window appears for entering the [Name] of the copy.



- 3 Enter the name of the interference avoidance data in [Name].
- 4 Click [OK].

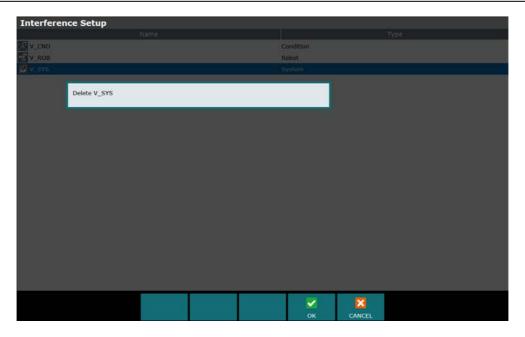
The copy is made.

Click [CANCEL] to cancel copying data.

4.1.1.4 Deleting

Use the following procedures to delete interference setup data:

- 1 On the interference avoidance data list screen, select the interference avoidance data to delete.
- 2 Click [DELETE] and a pop-up window appears for confirming deletion.

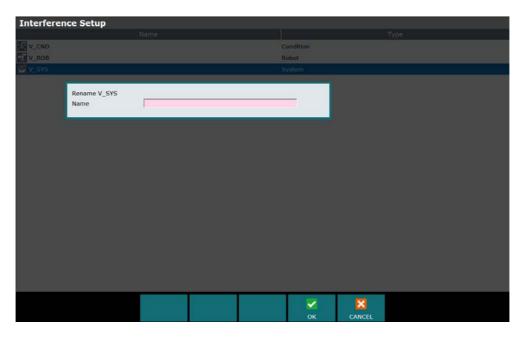


Click [OK].The selected data is deleted.Click [CANCEL] to cancel deleting data.

4.1.1.5 Renaming

Use the following procedures to rename interference avoidance data.

- 1 On the interference avoidance data list screen, select the interference avoidance data to rename.
- 2 Click [RENAME] and a pop-up window appears for renaming data.



- 3 For [Name], enter the new name.
- 4 Click [OK].

The interference avoidance data is renamed.

Click [CANCEL] to cancel renaming data.

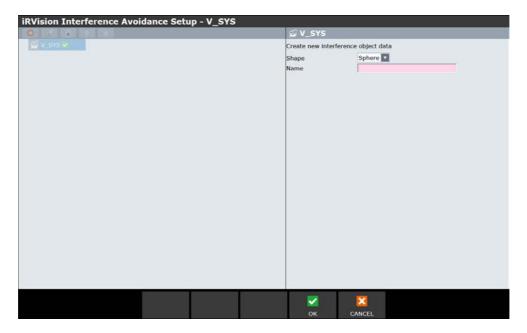
4.1.2 Operating Objects

To work with objects, select $[iRVision] \rightarrow [Interference Avoidance Setup]$ in the robot home page. On the ROBOT Homepage, select [iRVision], [Interference Avoidance Setup], and the interference avoidance data to operate the object on the interference avoidance data list screen, and then click [EDIT] to display the interference avoidance data edit screen.

4.1.2.1 Creating new data

Use the following procedure to create object data:

In the tree view of the edit screen for interference avoidance data, select an interference avoidance data name and click the button. A screen similar to the one below appears.



- 2 Select the shape of the object to create from the [Shape] drop-down box.
- 3 Enter the name of the object in [Name].
- 4 Click [OK].

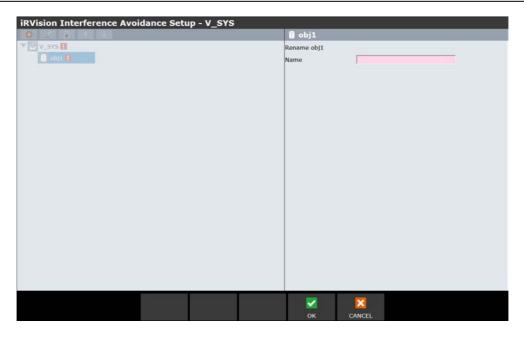
The object data is newly created.

Click [CANCEL] to cancel creating new data.

4.1.2.2 Renaming

Use the following procedure to rename object data:

- 1 In the tree view of the edit screen for interference avoidance data, select the object to rename.
- 2 Click the displayment button in the tree view. A screen similar to the one below appears.

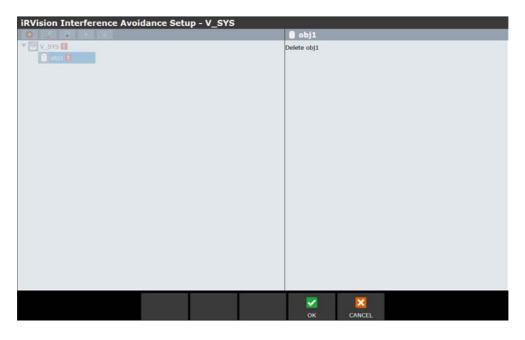


- 3 Enter the new name of the object in [Name].
- 4 Click [OK].
 The object data is renamed.
 - Click [CANCEL] to cancel renaming data.

4.1.2.3 Deleting

Use the following procedure to delete object data:

- 1 In the tree view of the edit screen for interference avoidance data, select the object to delete.
- 2 Click the button in the tree view. A screen similar to the one below appears.



Click [OK].The object data is deleted.Click [CANCEL] to cancel deleting data.

4.1.2.4 Moving data up and down

Use the following procedures to move the object data up/down.

- 1 In the tree view of the edit screen for interference avoidance data, select the object to move.
- 2 Click the 1 button in the tree view to move it up.
- 3 Click the **▼** button in the tree view to move it down.

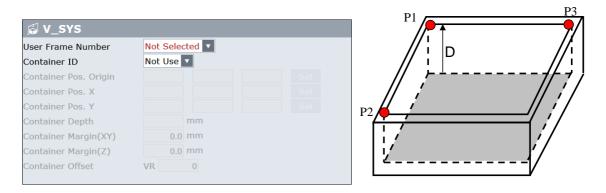
4.2 INTERFERENCE SETUP (SYSTEM)

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



4.2.1 Setting of User Frame Number and Container

The setting item area for system data contains the following parameters.



[User Frame Number]

Select the number of the user frame to use as the reference from the drop-down box.

[Container ID]

Select the container ID to use from the drop-down box. Once a container object is set, it is distinguished from others by using this ID and can be used in other system data by specifying the same container ID.

[Container Pos. Origin]

Enter the position of P1 in the above figure in the text box. Clicking the [Set] button sets [Container Pos. Origin] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

[Container Pos. X]

Enter the position of P2 in the above figure in the text box.

[Container Pos. Y]

Enter the position of P3 in the above figure in the text box.

[Container Depth]

Enter the D value in the above figure in the text box. The unit is mm.

[Container Margin (XY)]

Enter the XY-direction margin in the text box. The unit is mm. Setting a negative value makes the container size larger by the set value.

[Container Margin (Z)]

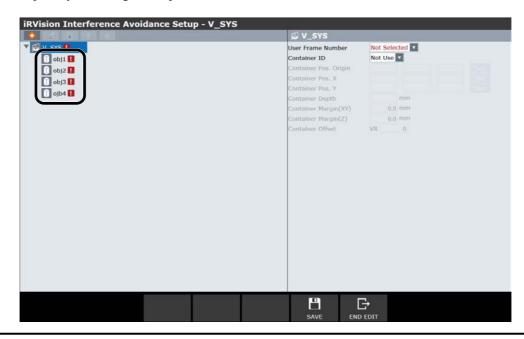
Enter the Z-direction margin in the text box. The unit is mm. If a positive value is set, the height of the top of the container is increased by the set value while the height of the bottom remains unchanged. Setting a negative value reduces the height of the top of the container by the set value.

[Container Offset]

To change the location of the container according to the result of the vision process, set the number of the vision register to use in [Container Offset]. To keep the location of the container unchanged, set 0.

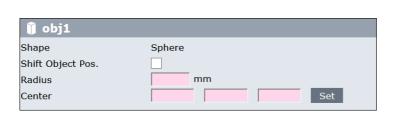
4.2.2 Setting of Fixed Object Data

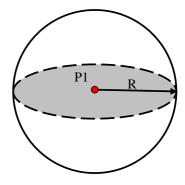
Set a fixed object by selecting the object name in the tree view of the edit screen.



4.2.2.1 Spherical fixed object

The setting item area for spherical fixed objects contains the following parameters.





[Shape]

The shape of the fixed object that was selected when you created it appears.

[Shift Object Pos.]

To move the set fixed object together with the container, select this check box.

[Radius]

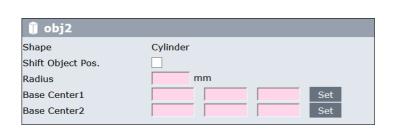
Enter the R value in the above figure in the text box. The unit is mm.

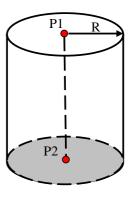
[Center]

Enter the position of P1 in the above figure in the text box. Clicking the [Set] button sets [Center] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected. For [User Frame Number], refer to "References: 4.2.1 Setting of User Frame Number and Container".

4.2.2.2 Cylindrical fixed object

The setting item area for cylindrical fixed objects contains the following parameters.





[Shape]

The shape of the fixed object that was selected when you created it appears.

[Shift Object Pos.]

To move the set fixed object together with the container, select this check box.

[Radius]

Enter the R value in the above figure in the text box.

[Base Center1]

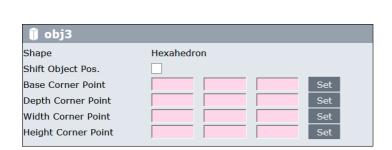
Enter the position of P1 in the above figure in the text box. Clicking [Set] sets [Base Center1] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

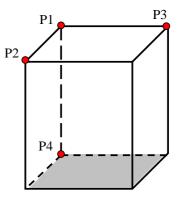
[Base Center2]

Enter the position of P2 in the above figure in the text box. Clicking [Set] sets [Base Center2] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

4.2.2.3 Hexahedron shaped fixed object

The setting item area for hexahedron shaped fixed objects contains the following parameters.





[Shape]

The shape of the fixed object that was selected when you created it appears.

[Shift Object Pos.]

To move the set fixed object together with the container, select this check box.

[Base Corner Point]

Enter the position of P1 in the above figure in the text box. Clicking the [Set] button sets [Base Corner Point] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

[Depth Corner Point]

Enter the position of P2 in the above figure in the text box. Clicking the [Set] button sets [Depth Corner Point] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

[Width Corner Point]

Enter the position of P3 in the above figure in the text box. Clicking the [Set] button sets [Width Corner Point] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

[Height Corner Point]

Enter the position of P4 in the above figure in the text box. Clicking the [Set] button sets [Height Corner Point] to the current robot position in the user frame that is set in [User Frame Number] and the tool frame that is currently selected.

4.2.2.4 3D map fixed object

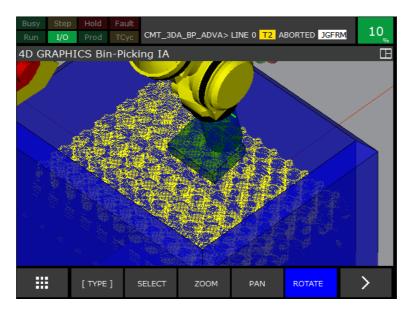
If another part is present around the part that you are trying to pick, picking may be obstructed by that another part and fail. To prevent such cases, set the 3D map acquired from the 3D Area Sensor to the fixed object shape. The setting item area contains the following parameters.



[3D Area Sensor]

Select the sensor data of the 3D Area Sensor to acquire a 3D map from the drop-down box.

A 3D map fixed object is shown as a yellow 3D point in 4D graphic.



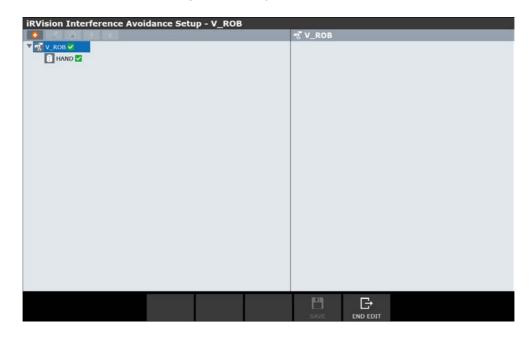
When a tool object interferes with a 3D map fixed object in 4D graphic, the 3D point of the 3D map is shown in light yellow.

MEMO

When you create a 3D map fixed object, all 3D maps acquired with the 3D Area Sensor set to the sensor data selected for [3D Area Sensor] are deemed as ones to avoid interference.

4.3 INTERFERENCE SETUP (ROBOT)

In the interference setup (robot), set data such as the position and size of grippers and other objects mounted on the robot end of arm tooling as a tool object.



⚠ CAUTION

Set the position of grippers and other objects in terms of the mechanical interface of the robot.

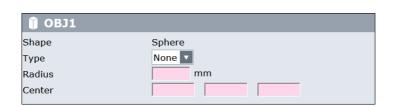
4.3.1 Setting the Tool Object

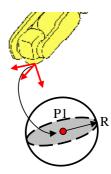
Set a tool object by selecting the object name in the tree view of the edit screen.



4.3.1.1 Spherical tool object

The setting item area for spherical tool objects contains the following parameters.





[Shape]

The shape of the tool object that was selected when you created it appears.

[Type]

Select [Type] from the drop-down box. Select from [None], [Camera], and [Hand]. If [Camera] or [Hand] is specified for [Type], interference can be avoided inside the container only for tool objects of the type specified for [Search Pos. Inside Container] in the interference setup (condition) data that is described later.

[Radius]

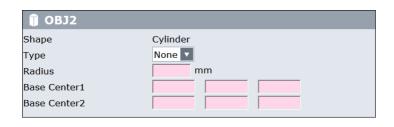
Enter the R value in the above figure in the text box.

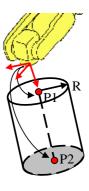
[Center]

Enter the position of P1 in the above figure in the text box.

4.3.1.2 Cylindrical tool object

The setting item area for cylindrical tool objects contains the following parameters.





[Shape]

The shape of the tool object that was selected when you created it appears.

[Type]

Select [Type] from the drop-down box. Select from [None], [Camera], and [Hand]. If [Camera] or [Hand] is specified for [Type], interference can be avoided inside the container only for tool objects of the type specified for [Search Pos. Inside Container] in the interference setup (condition) data that is described later.

[Radius]

Enter the R value in the above figure in the text box. The unit is mm.

[Base Center1]

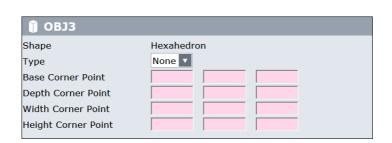
Enter the position of P1 in the above figure in the text box.

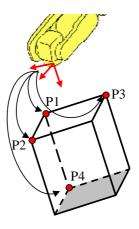
[Base Center2]

Enter the position of P2 in the above figure in the text box.

4.3.1.3 Hexahedron shaped tool object

The setting item area for hexahedron shaped tool objects contains the following parameters.





[Shape]

The shape of the tool object that was selected when you created it appears.

[Type]

Select [Type] from the drop-down box. Select from [None], [Camera], and [Hand]. If [Camera] or [Hand] is specified for [Type], interference can be avoided inside the container only for tool objects of the type specified for [Search Pos. Inside Container] in the interference setup (condition) data that is described later.

[Base Corner Point]

Enter the position of P1 in the above figure in the text box.

[Depth Corner Point]

Enter the position of P2 in the above figure in the text box.

[Width Corner Point]

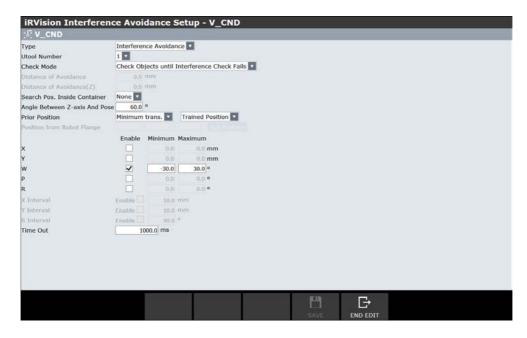
Enter the position of P3 in the above figure in the text box.

[Height Corner Point]

Enter the position of P4 in the above figure in the text box.

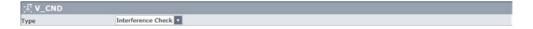
4.4 INTERFERENCE SETUP (CONDITION)

In an interference setup (condition), specify which of the following the created interference setup (system) and interference setup (robot) is to be used for: Interference check, Interference avoidance, and Wall avoidance. Items that must be set vary depending on the selection for [Type].



4.4.1 Setting of Data Type

The setting item area for data types contains the following parameters.

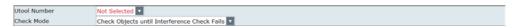


[Type]

Select [Type] from the drop-down box. Select [Type] from [Interference Check], [Interference Avoidance], and [Wall Avoidance] according to the desired function. Even if [Interference Avoidance] or [Wall Avoidance] is selected, specify the [Interference Check] settings that are described in the following section.

4.4.2 Setting of Interference Check

The setting item area for the interference check contains the following parameters.



[Utool Number]

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

[Check Mode]

Select either [Check Objects until Interference Check Fails] or [Check All Objects] from the drop-down box. If [Check Objects until Interference Check Fails] is selected and interference with an object occurs

during the interference check, no interference check will be performed on subsequent objects. If [Check All Objects] is selected, all objects will be checked for interference.

4.4.3 Setting of Wall Avoidance

The setting item area is enabled when [Wall Avoidance] is selected for [Type]. It contains the following parameters.

 Distance of Avoidance
 0.0 mm

 Distance of Avoidance(Z)
 0.0 mm

[Distance of Avoidance]

Enter how far the robot end of arm tooling should move to retreat from the wall toward the center of the container in the text box. The unit is mm.

[Distance of Avoidance(Z)]

Enter the Z-axis direction component for retreat in Wall Avoidance in the text box. The unit is mm.

4.4.4 Setting of Interference Avoidance

This can be set only if [Interference Avoidance] is selected for [Type]. It contains the following parameters.



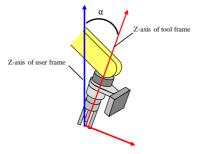
[Search Pos. Inside Container]

Select the type of equipment from [None], [Camera], [Hand], and [All].

The avoidance position will be calculated so that the objects belonging to the specified type of equipment will be inside the container.

[Angle Between Z-axis And Pose]

Enter the limit on the angle between the Z-axis of the user frame and the Z-axis of the tool frame selected for [Utool Number] in the text box. The unit is degrees. The output avoidance position and posture will be such that the α in the figure below does not exceed the value set here. If no such avoidance position and posture is found, it is judged that the interference avoidance position and posture calculation failed.

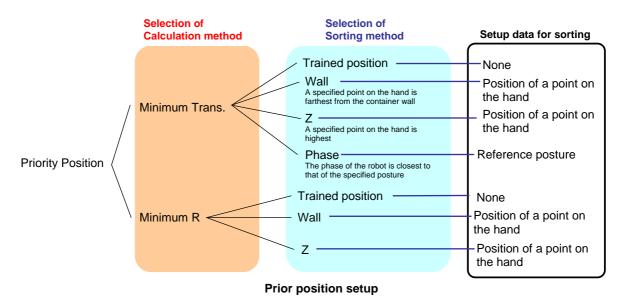


Limit on the Z-axis angle

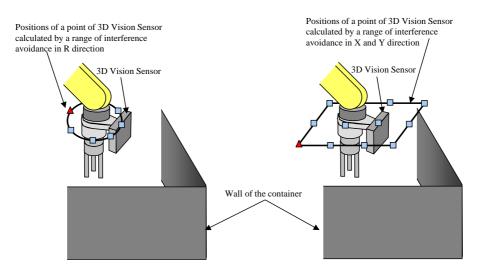
[Prior position]

Select the calculation method from the left drop-down box and the sorting method from the right drop-down box to set the prior position.

It consists of three components as the followings.



- Select the calculation method from the left drop-down box. Select [Minimum trans.] or [Minimum R].
 - If [Minimum trans.] is selected, the avoidance position and posture displaced in the R direction is preferentially calculated. If [Minimum R] is selected, the avoidance position and posture displaced in the X and Y directions is preferentially calculated.
- 2 Select the sorting method from the right drop-down box.
 - If [Minimum trans.] is selected for the calculation method, [Trained Position], [Wall], [Z], or [Phase] can be selected for the sorting method. Avoidance position and posture candidates displaced in the R direction are sorted by the selected condition and then their avoidance position and posture are calculated. Among the positions and postures that have succeeded in interference avoidance, those that best match the selected condition are output. If [Minimum R] is selected for the calculation method, [Trained Position], [Wall], or [Z] can be selected for the sorting method. Avoidance position and posture candidates displaced in the X and Y directions are sorted by the selected condition and then their avoidance position and posture are calculated. Among the positions and postures that have succeeded in interference avoidance, those that best match the selected condition are output. The figures in 'Sorting method selection example' below show examples in which [Wall] is selected and sorting is performed in such a way that 3D Laser Vision Sensor moves away from the wall of the container. The left figure below shows the sorting of avoidance positions and postures when [Minimum trans.] is selected for the calculation method. The right figure below shows the sorting of avoidance positions and postures when [Minimum R] is selected. In the right and left figures, the squares and triangles represent the positions of 3D Laser Vision Sensor when it moves to the avoidance position and posture candidates calculated from the avoidance range. Out of the avoidance position and posture candidates calculated from the respective ranges that have been set, specific avoidance positions and postures are calculated sequentially, starting with the triangle.

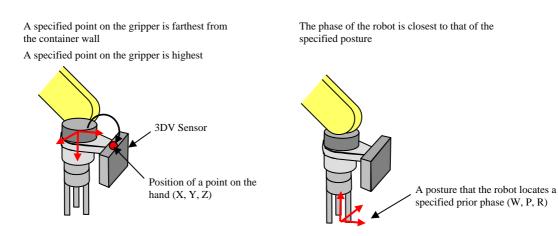


Sorting method selection example

3 Set up data required for sorting.

If [Wall] or [Z] is selected for the sorting method, set the position of a single point from the flange of the robot in the [Position from Robot Flange] text box. For this position, set the position on the gripper of the robot that is farthest from the container wall or that is the highest in the user frame (for example, the mounting position of the 3D Laser Vision Sensor).

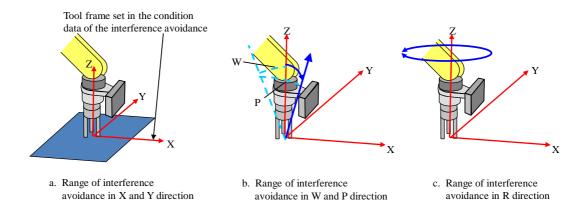
If [Phase] is selected for the sorting method, set the robot posture data in the phase to be prioritized (posture in the R direction of the tool frame) by clicking the [Set Posture] button in [Reference Posture].



Setup example of data required for sorting

[X], [Y], [W], [P], and [R]

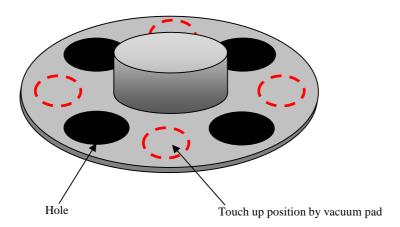
Specify the avoidance range. If the [Enable] box is checked, set [Minimum] and [Maximum] for the avoidance range. Set the amounts of change in the position and posture in the X and Y, W and P, or R direction in the tool frame selected for [Utool Number]. If the X and Y avoidance range is enabled, the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



Avoidance range example

[X Interval], [Y Interval], and [R Interval]

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



Positions where the vacuum pad touches when picking a workpiece with holes

[Time Out]

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

4.5 KAREL PROGRAM OF INTERFERENCE AVOIDANCE

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

IACHECK.PC

Calculates the interference between the tool object and the container or fixed objects that may occur when the robot moves to the target position and posture, and then outputs 0 in the register if no interference occurs or 1 if there is any interference. This program requires the following arguments.

Argument 1:

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

Argument 2:

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

Argument 3:

Specify the number of the vision register or position register where the offset value is set according to the offset type specified in argument 2. Specify the number of the vision register to use for vision offsetting if V is specified and the number of the position register to use for position offsetting if O is specified. If no offset is applied, specify 0.

Argument 4:

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

Argument 5:

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

Argument 6:

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

Argument 7:

Specify the name of the interference setup (condition) to be used.

Argument 8:

Specify the number of the register to output the interference check result to. The following result is stored in the register.

0: No interference

1: An interference occurs

IACALAVOID.PC

Calculates the interference between the tool object and the container or fixed object that may occur when the robot moves to the target position and the interference avoidance position (robot position where interference can be avoided). To obtain the interference avoidance position and posture calculated by IACALAVOID.PC, execute IAGETAVOID.PC that is described later. This program requires the following arguments.

Argument 1:

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

Argument 2:

Specify the type of offset to be applied to the robot position specified in argument 1. If V is

specified, the vision offset is applied. If O is specified, the position offset is applied. Even if no offset is applied, set either V or O.

Argument 3:

Specify the number of the vision register or position register where the offset value is set according to the offset type specified in argument 2. Specify the number of the vision register to use for vision offsetting if V is specified and the number of the position register to use for position offsetting if O is specified. If no offset is applied, specify 0.

Argument 4:

Specify the index number of the position register to which to apply the tool offset. The tool offset is applied in the same way as when J PR [ARG 1] VOFFSET, VR [ARG 2] Tool_Offset, PR [ARG 4] or J PR [ARG 1] Offset, PR [ARG 3] Tool_Offset, PR [ARG 4] are specified. When not applying the tool offset, specify 0.

Argument 5:

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

Argument 6:

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

Argument 7:

Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Interference Avoidance] set in [Type] on the setup screen.

Argument 8

Specify the index number of the register to which the number of calculated interference avoidance positions is output.

Argument 9:

Specify the number of the register to output the status of the interference avoidance calculation to. The following status is stored in the register.

0: Interference avoidance calculation succeeds.

- 11: All candidates of interference avoidance position are rejected by limitation of angle Between Z-axis And Pose
- 12: Interference avoidance calculation timed out.
- 13: No interference avoidance position is found.

IAGETAVOID.PC

Obtains the interference avoidance position and posture calculated by IACALAVOID.PC and stores them in the position register. When IAGETAVOID is executed, one of the interference avoidance positions calculated by IACALAVOID is output. When IAGETAVOID is repeated, an interference avoidance position other than the previously output one or ones is output as long as there is any different interference avoidance position. This program requires the following arguments.

Argument 1:

Specify the name of the interference setup (system) to be used. Specify the same value that is specified in IACALAVOID.

Argument 2:

Specify the name of the interference setup (robot) to be used. Specify the same value that is specified in IACALAVOID.

Argument 3:

Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Interference Avoidance] set in [Type] on the setup screen. Specify the same value that is specified in IACALAVOID.

Argument 4:

Specify the index number of the register to which to output the result of the operation of obtaining the interference avoidance position. The following status is stored in the register.

- 0: Successfully acquired the interference avoidance position and posture
- 1: Failed to acquire the interference avoidance position and posture

Argument 5:

Specify the index number of the position register to which to output the interference avoidance position.

Argument 6:

Specify the index number of the position register to which to output the tool offset value. When the robot picks up the workpiece at the interference avoidance position, the position of the gripper relative to the workpiece becomes different from that of the original target position. This makes it impossible to set the workpiece onto the fixture or machine. In that case, the tool offset needs to be applied.

IAAVDWALL.PC

Calculates and outputs the position offset value to be used to make the robot end of arm tooling retreat from the wall to the center of the container. This program requires the following arguments.

Argument 1:

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

Argument 2:

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

Argument 3:

Specify the number of the vision register or position register where the offset value is set according to the offset type specified in argument 2. Specify the number of the vision register to use for vision offsetting if V is specified and the number of the position register to use for position offsetting if O is specified. If no offset is applied, specify 0.

Argument 4:

Specify the index number of the position register to which to apply the tool offset. The tool offset is applied in the same way as when J PR [ARG 1] VOFFSET, VR [ARG 2] Tool_Offset, PR [ARG 4] or J PR [ARG 1] Offset, PR [ARG 3] Tool_Offset, PR [ARG 4] are specified. When not applying the tool offset, specify 0.

Argument 5:

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

Argument 6:

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

Argument 7:

Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Wall Avoidance] set in [Mode] on the setup screen.

Argument 8:

Specify the number of the register to output the status of the wall avoidance calculation to. The following status is stored in the register.

- 0: Successfully calculated the wall avoidance distance
- 1: Failed in the wall avoidance distance calculation

Argument 9:

Specify the index number of the position register to which to output the position offset value for wall avoidance.

5 PARTS LIST MANAGER REFERENCE

5.1 BASIC OPERATIONS OF PARTS LIST MANAGER

This section describes basic operations performed in Parts List Manager. One Parts List Manager is provided for each parts list. At first, there is one parts list, so when the data list screen for Parts List Manager is displayed, the setup data created for one Parts List Manager is shown.

MEMO

The number of data items that can be used by a Parts List Manager. However, the maximum number of data items that are available can be changed on the screen for the Parts List Manager configuration on the teach pendant. For details, refer to "Advanced Setup: 1.2 PARTS LIST MANAGER CONFIGURATION".

5.1.1 Setting Type

Parts List Manager can be one of the following three types.

SEARCH

Select this type if your bin picking system does not perform the FINE process. Parts List Manager of this type does not display items about the FINE process. This type of Parts List Manager has been created in advance.

SEARCH + FINE

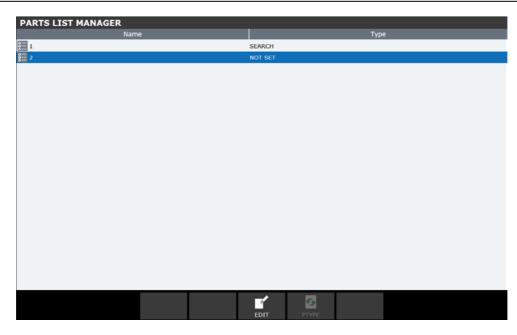
Select this type if your bin picking system performs the FINE process. This type can be selected and performed a bin picking system even if a bin picking system does not perform the FINE process.

Not Set

This type means that the type of a Parts List Manager is not set.

Before starting to set up a Parts List Manager, its type must be set. Set the type of a Parts List Manager according to the procedure described below:

- On the data list screen of Parts List Manager, select a Parts List Manager whose type is [NOT SET].
- 2 Click [EDIT].



A pop-up window appears for setting the type, so select a type for the parts list manager from the [Type] drop-down box.

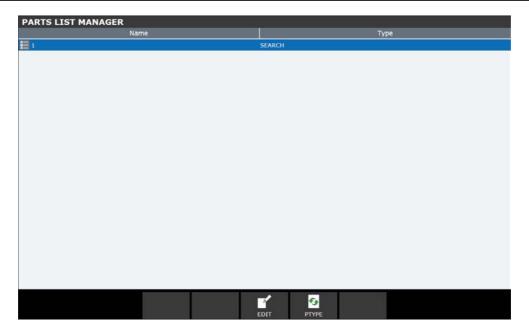


4 Click [OK].
The type is set.
Click [CANCEL] to cancel setting the type.

Opening the Parts List Manager Edit Screen

On the Parts List Manager edit screen, set items such as [SEARCH VP List] and [PICK Position List]. Use the following steps to display the edit screen for the parts list manager.

- 1 On the data list screen for parts list managers, select the parts list manager that you want to set up.
- 2 Click [EDIT].

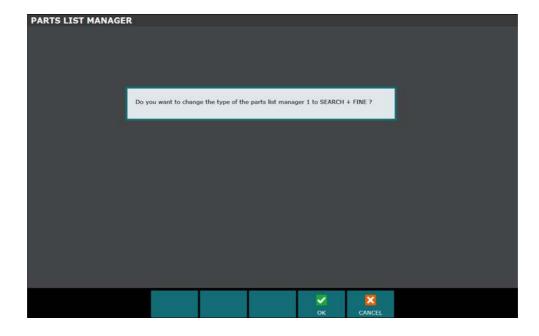


Changing Type

Change the type of a Parts List Manager according to the procedure described below:

- On the data list screen for parts list managers, select the parts list manager that you want to change the type of.
- 2 Click [PTYPE].
- A pop-up window appears for confirming the type change.
 The type is changed.
 Click [CANCEL] to cancel changing the type.

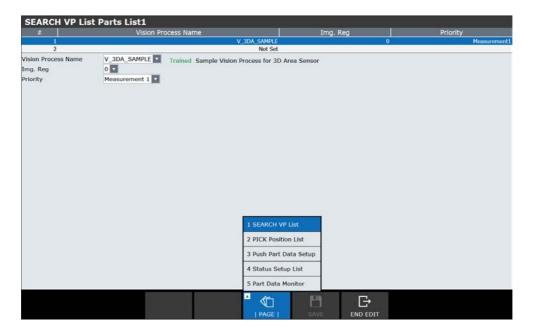
Even if you have changed the type of the Parts List Manager from [SEARCH + FINE] to [SEARCH], setting data about the FINE process is saved. So if you have changed the type of the Parts List Manager from [SEARCH+FINE] back to [SEARCH], setting data about the FINE process is restored.



5.1.2 Displaying the Desired Edit Screen of Parts List Manager

Parts list managers have several edit screens including [SEARCH VP List] and [Parts List Manager Setup]. Use the following procedures to change the edit screen.

- On the data list screen for parts list managers, select the parts list manager that you want to change the edit screen for.
- 2 Click [EDIT].
 - An edit screen similar to the one below appears.
- 3 Click [PAGE] and select an edit screen to display from the submenu. The edit screen for the parts list manager is changed.



Changing List Data

To change the list data on an edit screen that displays a list and setting items such as [SEARCH VP List] and [PICK Position List], use the following steps. Switch data in the list view according to the following procedure.

- 1 On the edit screen for the parts list manager, click [EDIT].
- 2 Click [PAGE] and select an edit screen to display from the submenu.
- 3 Select the row of the list that corresponds to the data that you want to change.
- 4 Specify each setting item.



5.2 BASIC RULES OF PARTS LIST MANAGER

This section describes the rules of the parts list and part data and things you need to know when using the Parts List Manager.

Parts List and part data

The following rules apply to parts lists and parts data.

- Data for parts lists and part data are lost when the robot controller power is shut off.
- Use a single parts list to manage part data for parts contained in one container.
- As an indicator of the timing when part data were added to parts lists, the number of pushes performed after the robot controller power is turned on is used.

Number of pushes

- When the robot controller power is cycled the number of pushes is initialized to 0.
- When part data are pushed to a parts list after performing the following operations, the number of pushes is incremented by one.
 - Turn on the power of the robot controller again
 - Pops a part data from a parts list

Status

The statuses that can be set for part data are shown below.

- AWAITING
- PICK SUCCESS
- PICK FAIL
- PICK IA FAIL
- PICK CL FAIL
- FINE SUCCESS
- FINE FAIL
- FINE IA FAIL
- FINE CL FAIL

Data included in parts lists

A parts list includes the following data.

- Part data list (detailed below)
- Number of pushes performed after the robot controller powers up (Current Number of Pushes)
- Number of pops performed after the robot controller powers up

Data included in part data

Part data includes the following data

- Part data ID
 - The ID number is uniquely assigned to part data when the part data is pushed to a parts list. The part data ID of the part data that is first pushed after the robot controller powers up is 1. The ID is incremented by one each time a part is pushed.
- Flag indicating whether the part data is popped
- Status
- Priority
- Count of the blacklist

- Detection result by SEARCH vision process
 - The vision process name, model ID, found position, offset, ten measurements, and user frame number in the found position are included.
- Detection result by FINE vision process
 - The vision process name, model ID, found position, offset, ten measurements, and user frame number in the found position are included.
- Number of pushes when the part is found by the SEARCH vision process and the part data corresponding to the found part is pushed to the parts list (Number of Pushes of Part Data)

 This data of the part data in the blacklist is updated when the part corresponding to the part data in the blacklist is found by the SEARCH vision process to the current total number of pushes. By comparing this data with the current total number of pushes, you can see whether this part data has been found recently.
- Number of pushes of the parts list when this part data is pushed to the blacklist.

5.3 PARTS LIST MANAGER SETUP AND PART DATA OPERATIONS

This section explains some necessary settings and operations for the following operations of the parts list manager.

- Clear all part data in a parts list
- Push some part data to a parts list
- Pop a part data from a parts list
- Calculate a PICK position
- Set a status for a popped part data
- Calculate a FINE position
- Execute a FINE vision process for a popped part data

5.3.1 Clear All Part Data in a Parts List

To clear all part data in a parts list, the following operations are required.

• Call BINPICK_CLEAR in a TP program

5.3.1.1 Call BINPICK_CLEAR in a TP program

Call BINPICK_CLEAR in a TP program to clear all part data in a parts list. BINPICK_CLEAR requires the following argument.

Argument 1:

Specify the index number of the Parts List.

BINPICK_CLEAR is the following macro program.

- 1: !Clears part data in a Parts
- 2: !List.
- 3.
- 4: !arg1:Parts List ID
- 5: CALL IPCLR(AR[1])

5.3.2 Push Some Part Data to a Parts List

To push some part data to a parts list, the following operations and settings are required.

- Set up the SEARCH VP List.
- Set up the parameters for deleting older part data when part data are pushed
- Set up the parameters for checking for duplicate part data when part data are pushed
- Call BINPICK_SEARCH in a TP program

5.3.2.1 Setting up the SEARCH Vision Process

Select [SEARCH VP List] from the sub menus displayed by clicking [PAGE] and set the vision process you want to execute as the [SEARCH] vision process.



The setting item area contains the following parameters.

[Vision Process Name]

Select the vision process to execute as SEARCH from the drop-down box.

[Img. Reg]

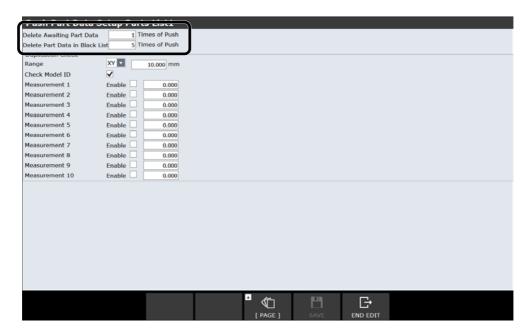
If you want to use the image register function, select the number of the image register to use from the drop-down box. If you do not want to use the image register function, select [0].

[Priority]

Select the measurement number (1-10) corresponding to the measurement to be set as the priority of part data from the drop-down box.

5.3.2.2 Set up the parameters for deleting older part data when part data are pushed

When part data are pushed, older part data in terms of the number of pushes are deleted. Set how old the part data should be for it to qualify for deletion. Select [Push Part Data Setup] for [PAGE] and set the following items.



The setting item area contains the following parameters.

[Delete Awaiting Part Data]

When part data is pushed, older part data (with a smaller number of pushes) is deleted. The following part data is deleted from the parts list: Its status is [Awaiting] and the value (Current Number of Pushes – Number of Pushes of Part Data) is greater than or equal to the value set in this text box.

[Delete Part Data in Blacklist]

When part data is pushed, older part data in the blacklist is deleted. The following part data in the blacklist is deleted from the parts list: The value (Current Number of Pushes – Number of Pushes of Part Data) is greater than or equal to the value set in this text box.

⚠ CAUTION

The deletion process of the part data is not performed for part data whose Number of Pushes of Part Data is same as the Current Number of Pushes.

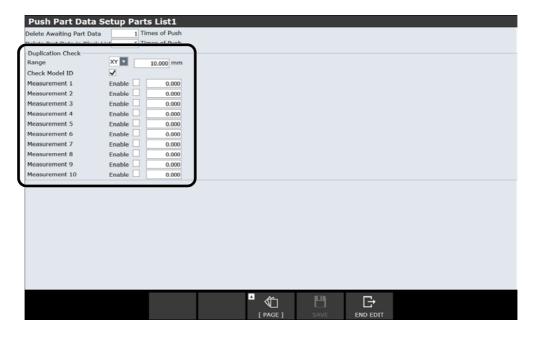
5.3.2.3 Duplication check

When new part data are pushed to the parts list, the new part data is checked to see if there is duplicate part data in the parts list. If there is duplicate part data in the parts list, the following processes are done.

- When the status of the duplicate part data is [Awaiting], the duplicate older part data is deleted and the new part data is pushed to the parts list.
- When the status of the duplicate part data is in the blacklist, the new part data is not pushed to the parts list and the Number of Pushes of Part Data of the duplicate older part data is updated.

Select [Push Part Data Setup] from the sub menus displayed by clicking [PAGE] and set the parameters

for checking for duplicate part data when part data are pushed.



[Range]

Set the distance between found positions that is used to determine whether multiple part data results in duplication. Select the type of the distance to compute from the drop-down box and specify the threshold of the distance in the text box. The unit is mm. The distance between the found position of the part data to be pushed into the parts list and the found position of each existing part data in the parts list is computed. If the computed distance is smaller than the threshold that is set here, the part data is considered to be duplicate.

[Check Model ID]

Specify whether to check model ID when determining if data is duplicate. With [Enable] checked, even if the conditions set in [Range] and [Measurement] are met, the part data with a different model ID is not considered to be duplicate.

[Measurement 1] ~ [Measurement 10]

Set a threshold that is used to determine whether the relevant part data is duplicate by using differences in measurement values in SEARCH results. Check the [Enable] check box for each measurement value that you want to use for the duplication check and set a threshold in the text box. When the absolute difference between the measurement value of the part data to be pushed into the parts list and the measurement value of each existing part data in the parts list is larger than the value that is set here, the relevant part data is not considered a duplicate even if the conditions set in [Range] and [Check Model ID] are met.



CAUTION

A part data is considered a duplicate when all of the conditions set for a duplication check are satisfied.

5.3.2.4 Call BINPICK_SEARCH in a TP program

Call BINPICK_SEARCH in a TP program to push some part data to a parts list. BINPICK_SEARCH requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the SEARCH vision process in SEARCH VP LIST.

Argument 3:

Specify the index number of a register to output the status of whether the SEARCH vision process is successful. One of the following values is output as the status:

- 0: Some Part Data are added to the specified Parts List.
- 1: No Part Data is added to the specified Parts List.

BINPICK SEARCH is the following macro program.

- 1: !Executes a SEARCH Vision
- 2: !Process. And Part Data are added
- 3: !to the Parts List according to
- 4: !the Vision Process.
- 5:
- 6: !arg1:Parts List ID
- 7: !arg2:Index number of the SEARCH
- 8: ! VP in SEARCH VP LIST
- 9: !arg3:Index number of R[] to set
- 10: ! the SEARCH status
- 11: ! 0:Part Data are added
- 12: ! 1:No Part Data is added
- 13: CALL IMSEARCH(AR[1],AR[2],0,AR[3])

5.3.3 Pop a Part Data from a Parts List

To pop a part data from a parts list, the following operation is required.

• Call BINPICK_POP in the TP program

⚠ CAUTION

The flag indicating whether the part data is popped is disabled after calling BINPICK SEARCH.

5.3.3.1 Call BINPICK_POP in a TP program

Call BINPICK_POP in a TP program to pop part data from a parts list. BINPICK_POP requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of a register to output the status of whether the SEARCH vision process is successful. One of the following values is output as the status:

0: SUCCESS

1: FAIL (No part data that can be popped)

Argument 3:

Specify the index number of a register to output the Model ID of the popped Part Data. This value is used to identify the type of the SEARCH Vision Process result.

Argument 4:

Specify the index number of a register to output the ID of the popped part data. This argument can be omitted. If omitted, the ID of popped part data will not be output.

BINPICK POP is the following macro program.

```
1: !Pops a Part Data from the
2: !specified Parts List.
3:
4: !arg1:Parts List ID
5: !arg2:Index number of R[] to set
6: ! status
7: ! 0:SUCCESS
8: ! 1:FAIL
9: !arg3:Index number of R[] to set
10: ! a model ID of a popped Part
11: ! Data
12: !arg4:Index number of R[] to set
13: ! a popped Part Data ID
14: ! (omissible)
14: CALL IMPOP(AR[1],AR[2],AR[3],AR[4])
```

5.3.4 Calculate a PICK Position

To calculate a PICK position, the following operations and settings are required.

- Set up the parameters for calculating a PICK position
- Set up the parameters for calculating a robot position to approach a part
- Set up the reference PICK position
- Call BINPICK_GETPICKPOS in a TP program

5.3.4.1 Set up the parameters for calculating a PICK position

Select [PICK Position List] from the sub menus displayed by clicking [PAGE] and set the parameters for calculating a robot position to pick up a part.



The setting item area contains the following parameters.

[Comment]

When multiple PICK positions are set, enter a comment to identify the relevant position. Up to 50 characters can be entered.

[Vision Process Name]

Select the name of the vision process used to get offset data or found positions from the drop-down box. When BINPICK_GETPICKPOS is called, a check is performed to determine if the SEARCH vision program name stored in the part data matches the vision program name selected here and any mismatch causes an alarm to be issued. With [Not Selected], no check is performed on the vision program name.

[Model ID]

Enter the model ID that is output by the vision process selected in the [Vision Process Name] text box. When BINPICK_GETPICKPOS is called, a check is performed to determine if the SEARCH model ID stored in the part data matches the model ID entered here and any mismatch causes an alarm to be issued. If [0] is set, no check is performed on the model ID.

[Interference Setup]

Set up the interference avoidance.

[Calculate IA]

Use this check box to select whether to calculate interference avoidance positions when the PICK position is calculated. When this box is checked, the drop-down boxes for selecting interference avoidance data that are located to the right of [IASYS], [IAROB], and [IACND] are enabled. Interference avoidance positions are calculated using the selected interference avoidance data.

[IASYS]

Select the interference setup (system) data that you want to use for calculating interference avoidance positions when the PICK position is acquired.

[IAROB]

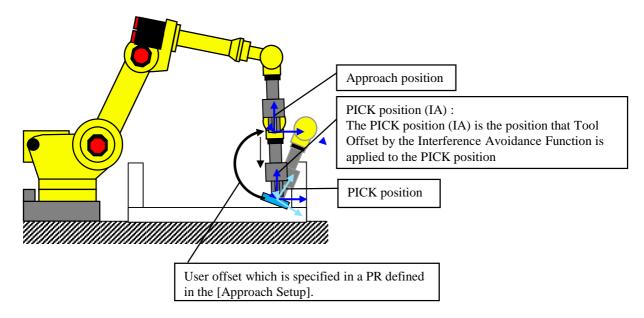
Select the interference setup (robot) data that you want to use for calculating interference avoidance positions when the PICK position is acquired.

[IACND]

Select the interference setup (condition) data that you want to use for calculating interference avoidance positions when the PICK position is acquired.

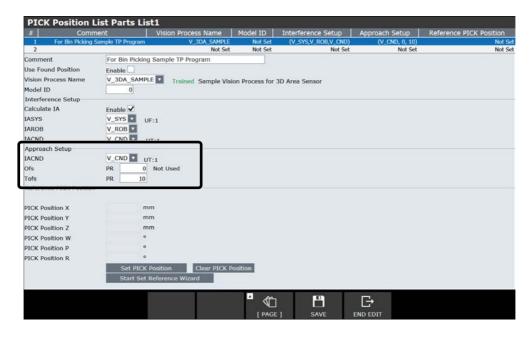
5.3.4.2 Set the parameters for calculating a robot position to approach a part

Set the parameters for calculating a robot position to approach a part.



Approach position calculation setup

To calculate the robot position to approach a part, set the following parameters. An approach position is calculated by applying the user offset specified in the [Approach Setup] to the PICK position (IA) shown in the figure above.



The setting item area contains the following parameters.

[IACND]

Select the interference setup data (condition) that you want to use to calculate interference avoidance positions at the approach position. The interference setup data (system) and interference setup data (robot)

used to calculate interference avoidance positions at the approach position are those selected for [IASYS] and [IAROB] in [Interference Setup].

[Ofs]

Enter the number of the position register where the position offset is set in the text box. The position offset is applied to a PICK position to calculate a position to approach a part. If you don't want to apply the position offset, set 0.

[TOfs]

Enter the number of the position register where the tool offset is set in the text box. The tool offset is applied to a PICK position to calculate a position to approach a part. If you don't want to apply the tool offset, set 0.

5.3.4.3 Set up the Reference PICK position

Set the reference PICK position to calculate a PICK position. Instead of them, the found position of the vision process can also be output as the PICK position without setting the reference PICK position.

Setting the reference PICK position

To set the reference PICK position, use the current robot position and posture or use the Set Reference Wizard.



The setting item area contains the following parameters.

[PICK Position X], [PICK Position Y], [PICK Position Z], [PICK Position W], [PICK Position P], [PICK Position R]

The reference PICK position is displayed. When no reference PICK position is set, you cannot change it. If you want to fine-tune a reference PICK position setup, change the value in the corresponding textbox.

[Set PICK Position] Button

Click the [Set PICK Position] button to set the current robot position and posture as the reference PICK position.

[Clear PICK Position] Button

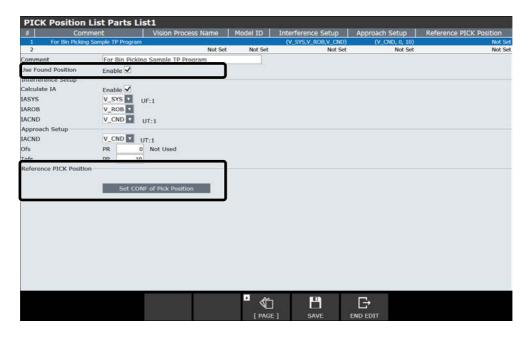
Clears the reference PICK position setups.

[Start Set Reference Wizard] Button

Starts the Set Reference Wizard to set the reference PICK position. For details, refer to "References: 5.5 SET REFERENCE WIZARD".

Using found positions

To output the found position of the vision process as the PICK position without setting the reference PICK position, set the following parameters.



[Use Found Position]

Check the checkbox if you want to use the found position as the PICK position.

[Set CONF of Pick Position] Button

If you want to use the found position as the PICK position, you must set the robot configuration to pick up a part. Click the [Set CONF of Pick Position] button to set the robot configuration to pick up a part.

5.3.4.4 Call BINPICK GETPICKPOS in a TP program

Call BINPICK_GETPICKPOS in a TP program to calculate a PICK position. BINPICK_GETPICKPOS requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the PICK position in the PICK POSITION LIST.

Argument 3:

Specify the index number of a register to output the status including whether the operation of obtaining the PICK position is successful. One of the following values is output as the status: 0: SUCCESS

12: Failed to get an interference avoidance position at the PICK position

13: Failed to get an interference avoidance position at the approach position

Argument 4:

Specify the index number of a position register to output the PICK position.

Argument 5:

Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the PICK position.

Argument 6:

Specify the index number of a position register to output an APPROACH position.

Argument 7:

Specify the part ID to obtain the PICK position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

BINPICK_GETPICKPOS is the following macro program.

```
1: !Calculates a PICK position.
3: !arg1:Parts List ID
4: !arg2:PICK POS ID in the PICK
5: ! POSITION LIST
6: !arg3:Index number of R[] to set
7: ! IA Status
8: ! 0:SUCCESS
9: ! 12:Fail to calc PICK POS
10: ! 13:Fail to calc APPROACH POS
11: !arg4:Index number of PR[] to set
12: ! PICK POS
13: !arg5:Index number of PR[] to set
14: ! IA offset value at PICK POS
15: !arg6:Index number of PR[] to set
16: ! APPROACH POS
17: !arg7:Part Data ID to obtain the
18: ! PICK POS (omissible)
19: CALL IMGETPICKPOS(AR[1],AR[2],AR[3],AR[4], AR[5],
   AR[6],0,AR[7])
```

5.3.5 Set a Status for Popped Part Data

The statuses that can be set for part data are shown below.

AWAITING

When a part data is pushed to a parts list, the part data is set to this status. The part data whose status is [Awaiting] is popped from the parts list as a candidate for the part data to be picked up.

PICK SUCCESS

The status indicates that the operation to pick up a part is done successfully. The part data that corresponds to the picked part is set to this status.

PICK FAIL

The status indicates that the operation to pick up a part was unsuccessful. The part data that corresponds to the picked part is set to this status.

PICK IA FAIL

The status indicates that the calculation of a PICK position was unsuccessful. The part data that corresponds to the part for which the calculation of a PICK position was unsuccessful is set to this status.

• PICK CL FAIL

When a collision occurs in the middle of the robot moving to the PICK position, the part data that corresponds to the part for which the PICK operation was attempted is set to this status.

FINE SUCCESS

The status indicates that the FINE vision process is done successfully. The part data that corresponds to the part for which the FINE vision process was successful is set to this status.

• FINE FAIL

The status indicates that the FINE vision process was unsuccessful. The part data that corresponds to the part for which the FINE vision process was unsuccessful is set to this status.

• FINE IA FAIL

The status indicates that the calculation of a FINE position was unsuccessful. The part data that corresponds to the part for which the calculation of a FINE position was unsuccessful is set to this status.

• FINE CL FAIL

When a collision occurs in the middle of the robot moving to the FINE position, the part data that corresponds to the part for which the PICK operation was attempted is set to this status.

Parts List Manager performs the following processing on part data when setting the status for the part data so that parts can be picked up efficiently by making the states of the parts in a container identical to the states of the part data in the parts list.

Delete

- Since a part is not present in the container if the part is picked up, the "PICK SUCCESS" status is set for the part data corresponding to the part that was picked up and the part data is deleted from the parts list.
- When a part is successfully picked up, parts close to the part that was picked up may have moved. If parts in the bin are moved, their data in the parts list is no longer valid. To prevent the robot from trying to pick based on the invalid positions, it is necessary to delete the part data corresponding to parts close to the part that was picked up before setting the "PICK SUCCESS" status for the part that was picked up. This is explained below in the "Deleting part data" section.

Registration in the blacklist

- To prevent the robot from repeatedly trying to pick an unpickable part, it is necessary to set the "PICK FAIL" status for the part data corresponding to the unpickable part and register the part data in the blacklist. The registration in the blacklist prevents the unpickable part from being popped again. A user specified positive count is set for the part data registered in the blacklist at the same time. When the count is decreased to 0, the part data is removed from the blacklist and then deleted from the parts list.
- When the following statuses are set to a part data, the part data can be registered in the blacklist.
 - PICK FAIL
 - PICK IA FAIL
 - PICK CL FAIL
 - FINE FAIL
 - FINE IA FAIL
 - FINE CL FAIL

To set a status for a part data, the following operation and setting are required.

- Set up the process when setting a status for a part data.
- Call BINPICK_SETSTAT in a TP program

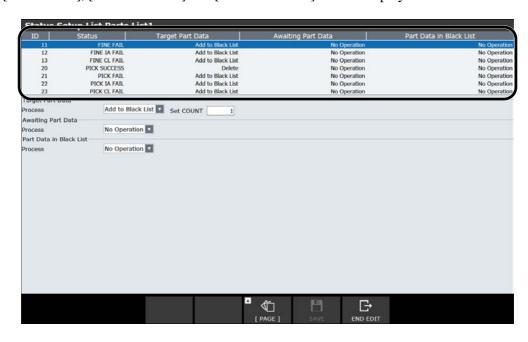
5.3.5.1 Set up the process when setting a status for a part data

Select [Status Setup List] from the sub menus displayed by clicking [PAGE] and set a process to be performed according to the status set for each part data.

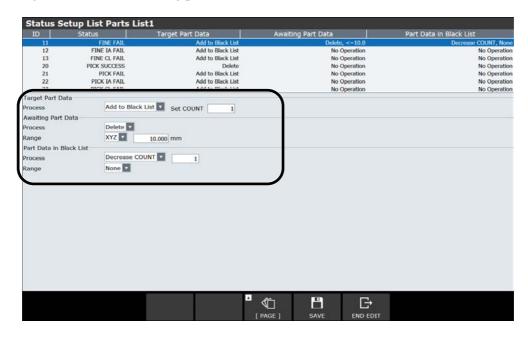
Selecting a status from the Status Setup List

The displayed [Status Setup List] edit screen contains a list view as shown below. The process to be performed according to each status set for part data is displayed in each line in the list. Select the line that

corresponds to the process you want to change. In a Parts List Manager whose type is [SEARCH], the lines of [FINE FAIL], [FINE IA FAIL] and [FINE CL FAIL] are not displayed.



After selecting status, set the following parameters.



[Target Part Data - Process]

Set the process to be performed for the target part data.

[Process]

Select the process to be performed for the target part data (part data for which a status is set). You can select either of the two processes: [Add to Black List] or [Delete]. When [PICK SUCCESS] is set for [Status], however, you can only select [Delete] as the process for target part data. If [Add to Black List] is selected for [Process], set the count value for the blacklist in the [Set COUNT] text box.

[Awaiting Part Data]

Set the process to be performed for the awaiting part data.

[Process]

Select the process to be performed for the target part data. Select from [No Operation] and [Delete].

[Range]

When setting a status for the target part data, perform the set process for any part data in the [Awaiting] status that are within the set range of the target part data. Set the range within which to perform the process.

Select the type of the distance to compute from the drop-down box and specify the threshold of the distance in the text box. The distance between the found position of the target part data and the found position of each existing part data in the parts list that is in the [Awaiting] status is computed. If the computed distance is smaller than the threshold that is set here, the process selected for [Process] is performed. If [All] is selected from the drop-down box for selecting the distance type, the selected process is performed for all the existing part data in the parts list that are in the [Awaiting] status.

This item will not be displayed if [No Operation] has been selected for [Process].

[Part Data in Blacklist - Process]

Set up the part data in the blacklist.

[Process]

Select the process to be performed for the part data in the blacklist. Select [No Operation], [Delete], [Set COUNT], or [Decrease COUNT]. If [Set COUNT] or [Decrease COUNT] is selected, enter the number by which to set or decrease the blacklist count.

[Range]

When setting a status for the target part data, perform the set process for any part data in the blacklist that are within the set range of the target part data. Set the range within which to perform the process.

Select the type of the distance to compute from the drop-down box and specify the threshold of the distance in the text box. The distance between the found position of the target part data and the found position of each existing part data in the parts list that is in the blacklist is computed. If the computed distance is smaller than the threshold that is set here, the process selected for [Process] is performed. If [All] is selected from the drop-down box for selecting the distance type, the selected process is performed for all the existing part data in the parts list that are in the blacklist.

This item will not be displayed if [No Operation] has been selected for [Process].

5.3.5.2 Call BINPICK_SETSTAT in a TP program

Call BINPICK_SETSTAT in a TP program to set a status for the popped part data. BINPICK_SETSTAT requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the status to be set to the popped Part Data. The following status can be set.

- 10: FINE SUCCESS
- 11: FINE FAIL
- 12: FINE IA FAIL
- 13: FINE CL FAIL
- 20: PICK SUCCESS
- 21: PICK FAIL
- 22: PICK IA FAIL
- 23: PICK CL FAIL

Argument 3:

Specify the part ID to set a status. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

BINPICK_SETSTAT is the following macro program.

```
1: !Sets a status to a popped Part
2: !Data.
3:
4: !arg1:Parts List ID
5: !arg2:Status to be set
6: ! 10:FINE SUCCESS
7: ! 11:FINE FAIL
8: ! 12:FINE IA FAIL
9: ! 13:FINE CL FAIL
10: ! 20:PICK SUCCESS
11: ! 21:PICK FAIL
12: ! 22:PICK IA FAIL
13: ! 23:PICK CL FAIL
14: !arg3:Part Data ID to set a
15: ! status (omissible)
16: CALL IMSETSTAT(AR[1],AR[2],AR[3])
```

5.3.6 Calculate a FINE Position

To calculate a FINE position, the following operations and settings are required. Also, the type of the parts list manager should be set to [SEARCH + FINE].

- Set up the parameters for calculating a FINE position
- Set up the reference FINE position
- Call BINPICK_GETFINEPOS in a TP program

5.3.6.1 Set up the parameters for calculating a FINE position

Select [FINE Position List] from the sub menus displayed by clicking [PAGE] and set data required for getting a FINE position and a reference FINE position.



[Comment]

When multiple FINE positions are set, enter a comment to identify the relevant position. Up to 50 characters can be entered.

[Vision Process Name]

Select the name of the vision process used to get offset data or found positions from the drop-down box. When BINPICK_GETFINEPOS is called, a check is performed to determine if the SEARCH vision program name stored in the part data matches the vision program name selected here and any mismatch causes an alarm to be issued. With [Not Selected], no check is performed on the vision program name.

[Model ID]

Enter the model ID that is output by the vision process selected in the [Vision Process Name] text box. When BINPICK_GETFINEPOS is called, a check is performed to determine if the SEARCH model ID stored in the part data matches the model ID entered here and any mismatch causes an alarm to be issued. If [0] is set, no check is performed on the model ID.

[Interference Setup]

Set up the interference avoidance.

[Calculate IA]

Use this check box to select whether to calculate interference avoidance positions when a FINE position is obtained. When this box is checked, the drop-down boxes for selecting interference avoidance data that are located to the right of [IASYS], [IAROB], and [IACND] are enabled. Interference avoidance positions are calculated using the selected interference avoidance data.

[IASYS]

Select the interference setup (system) data that you want to use for calculating interference avoidance positions when the FINE position is obtained.

[IAROB]

Select the interference setup (robot) data that you want to use for calculating interference avoidance positions when the FINE position is obtained.

[IACND]

Select the interference setup (condition) data that you want to use for calculating interference avoidance positions when the FINE position is obtained.

5.3.6.2 Set up the reference FINE position



[FINE Position X], [FINE Position Y], [FINE Position Z], [FINE Position W], [FINE Position P], [FINE Position R]

The reference FINE position is displayed. When no reference FINE position is set, you cannot change it. If you want to fine-tune a reference FINE position setup, change the value in the corresponding text box.

[Set FINE Position] Button

Click the [Set FINE Position] button to set the current robot position and posture as the reference FINE position.

[Clear FINE Position] Button

Clears the reference FINE position setups.

[Start Set Reference Wizard] Button

Click the [Start Set Reference Wizard] button to start the Set Reference Wizard to set the reference FINE position. For the Set Reference Wizard, refer to "References: 5.5 SET REFERENCE WIZARD".

5.3.6.3 Call BINPICK_GETFINEPOS in a TP program

Call BINPICK_GETFINEPOS in a TP program to calculate a FINE position. BINPICK_GETFINEPOS requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the FINE position in FINE POSITION LIST.

Argument 3:

Specify the index number of a register to output the status of whether the operation of obtaining the FINE position is successful. One of the following values is output as the status:

0: SUCCESS

11: NG

Argument 4:

Specify the index number of a position register to output the FINE position.

Argument 5:

Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function.

Argument 6:

Specify the part ID to obtain the FINE position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

BINPICK_GETFINEPOS is the following macro program.

```
1: !Calculates a FINE Position.
3: !arg1:Parts List ID
4: !arg2:Index number of FINE POS in
5: ! FINE POSITION LIST
6: !arg3:Index number of R[] to set
7: ! IA status
8: ! 0:SUCCESS
9: ! 11:FAIL
10: !arg4:Index number of PR[] to set
11: ! FINE POS
12: !arg5:Index number of PR[] to set
13: ! IA offset value at FINE POS
14: !arg6:Part Data ID to obtain the
15: ! FINE POS (omissible)
16: CALL IMGETFINEPOS(AR[1],AR[2],AR[3],AR[4],AR[5],
   AR[6])
```

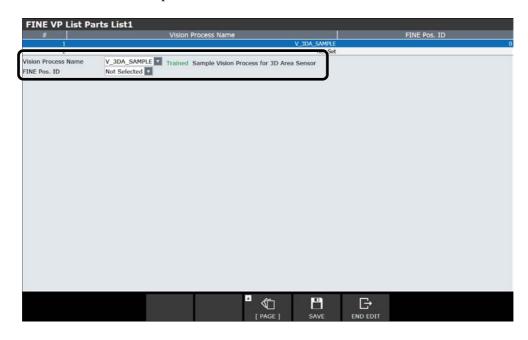
5.3.7 Execute a FINE Vision Process for a Popped Part Data

To execute a FINE vision process for a popped part data, the following operations and settings are required. Also, the type of the parts list manager should be set to [SEARCH + FINE].

- Set up the parameters for executing a FINE vision process
- Call BINPICK_FINE in a TP program

5.3.7.1 Set up the parameters for executing a FINE vision process

Select [FINE VP List] from the sub menus displayed by clicking [PAGE] and set the vision process you want to execute as the FINE vision process.



[Vision Process Name]

Select the vision process you want to execute as the FINE vision process from the drop-down box.

[FINE Pos. ID]

Select the ID of the FINE position you want to use. This item is used to calculate the position at which a FINE vision process is executed in the Set Reference Wizard.

5.3.7.2 Call BINPICK_FINE in a TP program

Call BINPICK_FINE in a TP program to execute a FINE vision process. BINPICK_FINE requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the FINE vision process in the FINE VP LIST.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: SUCCESS

1: NG

Argument 4:

Specify the index number of a register to output the Model ID of the FINE Vision Process result.

Argument 5:

Specify the Part Data ID to execute the FINE Vision Process operation. This argument can be omitted. If this argument is omitted, the FINE Vision Process operation is done to the popped Part Data.

BINPICK_FINE is the following macro program.

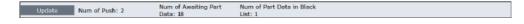
```
1: !Executes a FINE Vision Process.
2:
3: !arg1:Parts List ID
4: !arg2:Index number of the FINE VP
5: ! in FINE VP LIST
6: !arg3:Index number of R[] to set
7: ! FINE Status
8: ! 0:SUCCESS
9: ! 1:FAIL
10: !arg4:Index number of R[] to set
11: ! Model ID of FINE VP result
12: !arg5:Part Data ID to set FINE
13: ! result (omissible)
14: CALL IMFINE(AR[1],AR[2],AR[3],AR[4],AR[5])
```

5.4 PART DATA MONITOR

Select [Part Data Monitor] from the sub menus displayed by clicking [PAGE] and check parts list information and information of part data in the parts list.



Click the [Update] button on the edit screen to display the information on the parts list as shown in the figure below:



The setting item area contains the following parameters.

[Num of Push]

Number of times the part data were pushed into the parts list after the robot controller powered up.

[Num of Awaiting Part Data]

Number of part data items in the parts list whose status is [Awaiting]. When this value is 0, there are no parts that can be picked up.

[Num of Part Data in Black List]

Number of part data items in the blacklist in the parts list

The part data in the parts list appears in list view format.

#	ID	Pop	Status	COUNT	Priority	Found	Vision Process	Model ID	X	Υ	Z
1	1	0	21	1	97.99	1	V_3DA_SAMPLE	1	1201.88	-159.51	77.5
2	25	1	21	1	97.44	2	V_3DA_SAMPLE	1	1197.34	20.85	71.8
3	26	0	1		97.40	2	V_3DA_SAMPLE	1	1207.99	-48.57	71.4
4	27	0	1		97.39	2	V_3DA_SAMPLE	1	1211.35	-94.64	71.2
5	28	0	1		97.32	2	V_3DA_SAMPLE	1	1337.08	-268.91	70.5
6	29	0	1		97.25	2	V_3DA_SAMPLE	1	1449.22	-32.95	69.7
7	30	0	1		97.23	2	V 3DA SAMPLE	1	1452.08	-104.96	69.5

The following items appear in the list view.

[#]

Order in the parts data

[ID]

ID of the part data.

[Pop]

Whether the part data is popped. When the part data is popped, 1 is displayed. When it is not popped, 0 is displayed.

[Status]

Status of the part data. One of the following numbers indicating the status is displayed:

- 1: Awaiting
- 11: FINE FAIL
- 12: FINE IA FAIL
- 13: FINE CL FAIL
- 21: PICK FAIL
- 22: PICK IA FAIL
- 23: PICK CL FAIL

[COUNT]

Blacklist count when the part data is in the blacklist. When there is no part data in the blacklist, nothing appears.

[Priority]

Priority of the part data.

[FIND]

Number of pushes when the part is found by the SEARCH vision process and the part data corresponding to the found part is pushed to the parts list (Number of Pushes of Part Data). This data of the part data in the blacklist is updated to the current total number of pushes when the part corresponding to the part data in the blacklist is found by the SEARCH vision process. By comparing this data with the current total number of pushes, you can see whether this part data has been found recently.

[Vision Process]

Name of the vision process executed as the SEARCH vision process.

[Model ID]

Model ID of the found result of the vision process executed as the SEARCH vision process.

[X], [Y], [Z]

The found position of the part found by the vision process executed as the SEARCH vision process. The found position is the position of the part in the offset user frame.

If you select a line in the list, more detailed information of the part data on the selected line is displayed as shown below.

```
Part ID
Pop
Status
Priority
                       97.40
Add to Parts List
Add to Black List
Latest Found
                      V 3DA SAMPLE
SEARCH Vision Process
SEARCH Model ID
SEARCH Found Position (1207.99, -48.57, 71.40, 0.00, 0.00, 0.00)
SEARCH Vision Offset
                       ( -3.74, 39.98, -2.21, 0.00, 0.00, 0.00)
                      ( 97.40, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00)
SEARCH Measurements
FINE Vision Process
FINE Found Position
                      ( 0.00, 0.00, 0.00, 0.00, 0.00, 0.00)
FINE Vision Offset
                      ( 0.00, 0.00, 0.00, 0.00, 0.00, 0.00)
                      ( 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00)
FINE Measurements
```

The setting item area contains the following parameters.

[Part ID]

ID of the part data.

[Pop]

Whether the part data is popped. When the part data is popped, 1 is displayed. When it is not popped, 0 is displayed.

[Status]

Status of the part data.

[Priority]

Priority of the part data.

[Add to Parts List]

Number of pushes when part data is added to the parts list.

[Add to Black List]

Number of pushes when part data is added to the blacklist.

[FIND]

Number of pushes when the part is found by the SEARCH vision process and the part data corresponding to the found part is pushed to the parts list (Number of Pushes of Part Data). This data of the part data in the blacklist is updated to the current total number of pushes when the part corresponding to the part data in the blacklist is found by the SEARCH vision process. By comparing this data with the current total number of pushes, you can see whether this part data has been found recently.

[SEARCH Vision Process]

Name of the vision process executed as the SEARCH vision process.

[SEARCH Model ID]

Model ID of the found result of the vision process executed as the SEARCH vision process.

[SEARCH Found Position]

The found position of the part found by the vision process executed as the SEARCH vision process. The found position is the position of the part in the offset user frame.

[SEARCH Vision Offset]

Vision offset for the vision process executed as the SEARCH vision process.

[SEARCH Measurements]

Measurement values obtained by the vision process executed as the SEARCH vision process.

[FINE Vision Process]

Name of the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

[FINE Model ID]

Model ID of the found result of the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

[FINE Found Position]

Position found by the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

[FINE Vision Offset]

Vision offset for the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

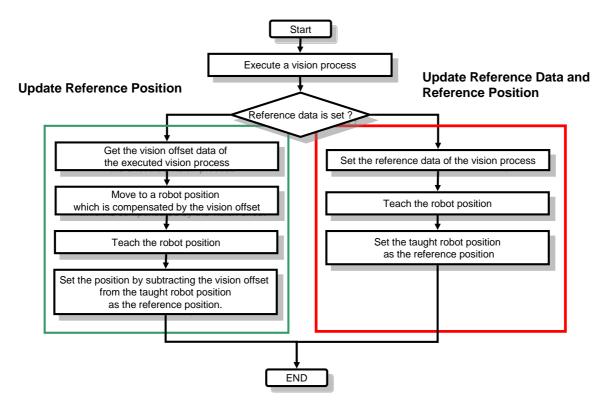
[FINE Measurements]

Measurement values obtained by the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

5.5 SET REFERENCE WIZARD

When you use the Parts List Manager, if you want to teach or reteach the reference position, use the Set Reference Wizard.

To set up a reference position that is compensated for with a vision offset, the steps described in the following figure are required. The Set Reference Wizard displays the steps described in the following figure in wizard form. By following the steps displayed by the wizard, you can teach or reteach the reference position.

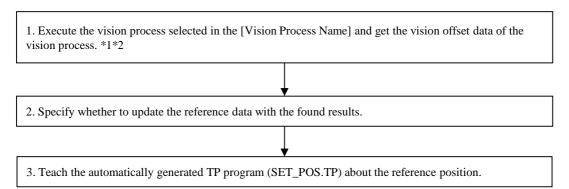


Reference position setting steps

The wizard allows you to teach the reference position easily without any errors even when the system has many reference PICK positions or reference FINE positions. The Set Reference Wizard is started by clicking the [Start Set Reference Wizard] button that appears when [PICK Position List] is selected from [PAGE]. If the [Start Set Reference Wizard] button does not appear with [PICK Position List] being selected, ensure that [Use Found Position] is not checked.

5.5.1 Basic Flow of Set Reference Wizard Operations

When you use the Set Reference Wizard, follow the steps shown in the figure below to set one reference position.



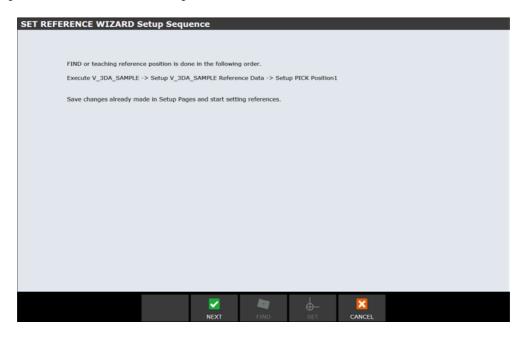
- *1 When no data is set for [Vision Process Name], detection is not performed, and 0 is set for all the offset elements [X], [Y], [Z], [W], [P], and [R].
- *2 It is also possible to set the reference position found by a vision process when that process executes detection. In that case, 0 is set for all the offset elements all the offset elements [X], [Y], [Z], [W], [P], and [R].

Process steps for the Set Reference Position Wizard

The values obtained by subtracting the offset values acquired in Step 1 from the position and posture taught to the TP program in Step 3 are set to the parts list manager as the reference position.

5.5.2 Details of Each Teaching Operation

After you start the Set Reference Wizard, the following screen appears for reviewing the teaching order. Click [NEXT] and perform operations described in "References: 5.5.1 Basic Flow of Set Reference Wizard Operations" for each reference position.



Perform operations according to the following three screens to set a reference position.

[Vision Execution screen]

This screen is for executing a vision process to get a vision result.

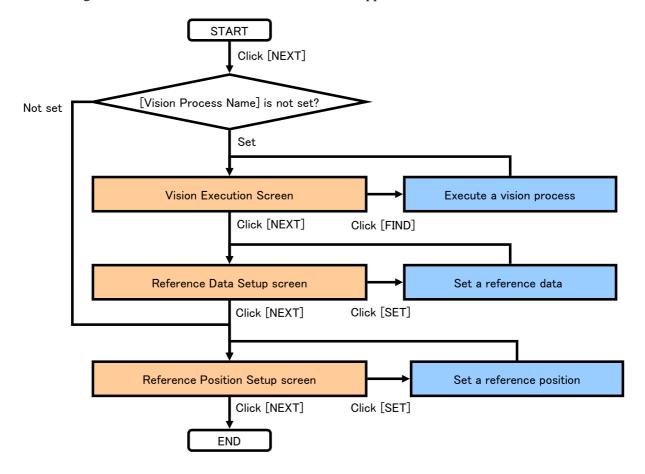
[Reference Data Setup screen]

This screen is for confirming that the found position of the found result executed on the Vision Execution screen is set as the reference data of its vision process.

Reference position setup screen

This screen is for confirming that the position taught to P [1] of the TP program is set as a reference position.

The following flow chart shows how and when each screen appears.

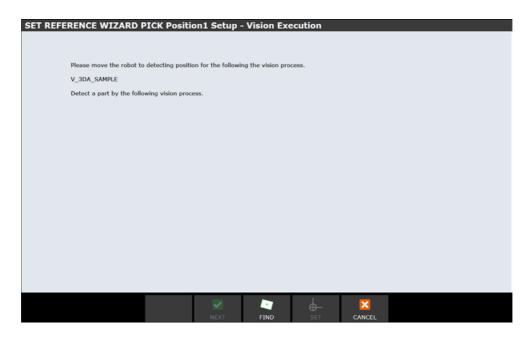


Screens that are part of the Set Reference Wizard

For details of operation corresponding to each screen, refer to the following subsections.

5.5.2.1 Vision Execution screen

When a vision process is set to the [Vision Process Name], the Vision Execution screen is displayed as follows.



On the [Vision Execution] screen, the following function keys are available.

[NEXT]

The [Reference Data Setup] screen appears. At first, this function key is disabled and cannot be selected. The function key is enabled after executing the vision process for detection.

[FIND]

Execute the vision process displayed on the screen. Open the Vision Runtime screen to confirm that the found result is correct.

Before executing the vision process, note the following points:

- To execute SEARCH with the fixed cameras or the 3D area sensor, move the robot so that it is not contained in the image, and then click [FIND].
- To execute the vision process for detection with the cameras mounted to the gripper, move the robot to a measurable position, and then click [FIND].

[CANCEL]

Terminate the wizard.

5.5.2.2 Reference Data Setup screen

This screen is for confirming that the found position of the vision result on the Vision Execution screen is set as the reference data of it. Please set the reference data of the vision process when no reference data is set for the vision process or its reference data must be updated.



On the [Reference Data Setup] screen, the following function keys are available.

[NEXT]

The [Reference Position Setup] screen appears. When the reference data for the vision process has already been set and you want to reteach the reference position only, do not perform any operations on this screen, and proceed to "References: 5.5.2.3 Reference Position Setup Screen".

[SET]

Set the found position of the found result executed on the Vision Execution screen as the reference data of its vision process.

When you use one vision process to compensate for multiple robot taught positions (reference positions), if you update the reference data of the vision process, you must reteach all of the reference positions displayed in the message (reference positions compensated for by the vision process). In the following cases, click [SET]:

- No reference data is set for the vision process.
- It is necessary to modify a model found by pattern matching and update the reference data for the vision process.
- You want to update the reference data for the vision process.

[CANCEL]

Terminate the wizard.

5.5.2.3 Reference position setup screen

If you start the Set Reference Wizard at a reference position where the [Vision Process Name] setting item is not set or if you click [NEXT] on the [Reference Data Setup] screen, the [Reference Position Setup] screen appears and a program named SET_POS.TP as shown below is generated.

⚠ CAUTION

Pay careful attention because if a TP program named SET_POS.TP already exists, its contents will be overwritten.

- 1: UFRAME NUM=1
- 2: UTOOL_NUM=1
- 3: L P[1] 100mm/sec FINE

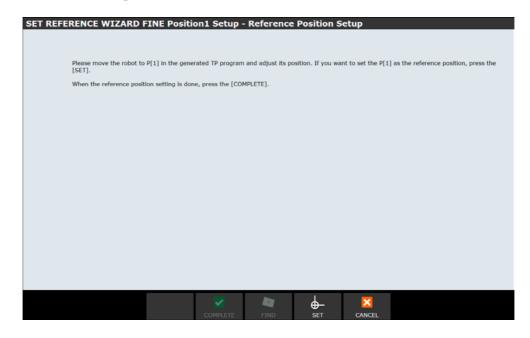
The following value is set to P [1]:

- When the reference position has been set: The position and posture obtained by applying the vision offset to the reference position and posture
- When no reference position is set: The position found by the previously executed vision process

The following values are set for UFRAME_NUM and UTOOL_NUM:

- When interference data has been set:
 - The user frame number and tool frame number selected in the interference data
- When no interference data is set and the reference position has been set: The user frame number and tool frame number used for the reference position already set
- When neither interference data nor a reference position is set: The currently selected user frame number and tool frame

The Reference Position Setup screen is as follows.



On the [Reference Position Setup] screen, the following function keys are available.

[NEXT], [COMPLETE]

Move to the next reference position setup screen. If there is no reference position to be set, [COMPLETE] is displayed in place of NEXT.

[SET]

Set the reference position. The position and posture obtained by subtracting the currently obtained vision offset from the position taught in P [1] in SET_POS.TP are set as the reference position in the Parts List Manager. Click Set after moving the robot to the intended position and touching up P [1]. As described above, the position and posture taught in the past or the position found by the vision process are set in P [1] before reteaching. For this reason, you can execute the TP program to reproduce P [1] before teaching, move the robot near the part, and then make adjustments by jogging to easily set the reference position.

[CANCEL]

Terminate the wizard.

5.6 KAREL PROGRAM

The following KAREL programs are available for part lists.

5.6.1 KAREL Programs of Parts List Manager

The Parts List Manager provides the following KAREL programs.

IMSEARCH.PC

Select a SEARCH vision process from the SEARCH VP LIST and execute the SEARCH vision process. And some Part Data created by SEARCH vision process result are added to the parts list. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the SEARCH vision process in SEARCH VP LIST.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Some Part Data are added to the specified Parts List.

1: No Part Data is added to the specified Parts List.

IMPOP.PC

Pop a part data from the specified Parts List. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: SUCCESS

1: FAIL (No part data that can be popped)

Argument 3:

Specify the index number of a register to output the Model ID of the popped Part Data. This value is used to identify the type of the SEARCH Vision Process result.

Argument 4:

Specify the index number of a register to output the ID of the popped part data. This argument can be omitted. If omitted, the ID of popped part data will not be output.

IMGETFINEPOS.PC

Calculate a FINE position from an offset value by a SEARCH vision process and a reference FINE position. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the FINE position in FINE POSITION LIST.

Argument 3:

Specify the index number of a register to output the status of whether the operation of obtaining the FINE position is successful. One of the following values is output as the status:

0: SUCCESS

11: NG

Argument 4:

Specify the index number of a position register to output the FINE position.

Argument 5:

Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function.

Argument 6

Specify the part ID to obtain the FINE position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

IMFINE.PC

Select a FINE vision process from the FINE VP LIST and execute the FINE vision process. A found result is set to a popped Part Data or a Part Data specified by Part Data ID. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the FINE vision process in the FINE VP LIST.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: SUCCESS

1: NG

Argument 4:

Specify the index number of a register to output the Model ID of the FINE Vision Process result.

Argument 5:

Specify the Part Data ID to execute the FINE Vision Process operation. This argument can be omitted. If this argument is omitted, the FINE Vision Process operation is done to the popped Part Data.

IMGETPICKPOS.PC

Calculate a PICK position from an offset value by a FINE vision process or a SEARCH vision process and a reference PICK position. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the index number of the PICK position in the PICK POSITION LIST.

Argument 3:

Specify the index number of a register to output the status including whether the operation of obtaining the PICK position is successful. One of the following values is output as the status:

0: SUCCESS

- 12: Failed to get an interference avoidance position at the PICK position
- 13: Failed to get an interference avoidance position at the approach position

Argument 4:

Specify the index number of a position register to output the PICK position.

Argument 5:

Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the PICK position.

Argument 6:

Specify the index number of a position register to output an APPROACH position.

Argument 7:

Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the APPROACH position.

Argument 8:

Specify the part ID to obtain the PICK position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

IMSETSTAT.PC

Sets the status for popped Part Data. By executing the KAREL program, the process set on the Parts List Manager edit screen is executed. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the status to be set to the popped Part Data. The following status can be set.

- 10: FINE SUCCESS
- 11: FINE FAIL
- 12: FINE IA FAIL
- 13: FINE CL FAIL
- 20: PICK SUCCESS
- 21: PICK FAIL
- 22: PICK IA FAIL
- 23: PICK CL FAIL

Argument 3:

Specify the part ID to set a status. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

5.6.2 KAREL Programs for Customizing the Parts List

The following KAREL programs are available for customizing the parts list.

IPCLR.PC

Clears the part data in a parts list. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

IPCRT.PC

Obtains the found result from the specified vision process and creates part data. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the name of a vision process.

Argument 3:

Specify the measurement number (1 to 10) for which the measurement to be set as the priority of the created part data is set.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Successfully created part data.

2: Failed to create part data because there was no found result the vision process could output due to a position not found error.

999: Failed to create part data due to an alarm other than a position not found error that occurred during find operation by the vision process.

This KAREL program only creates part data and does not push it in the parts list. To push part data to the parts list, after executing IPCRT.PC, execute IPPUSH.PC described below.

IPPUSH.PC

Pushes part data created by IPCRT.PC in a parts list. It is necessary to create part data using IPCRT.PC before executing IPPUSH.PC. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Successfully pushed part data in the parts list.

1: Failed to push parts data in the parts list because there was no part data that could be pushed.

999: Failed to push part data in the parts list due to an alarm other than the above (there was no part data that could be pushed).

Argument 3:

Specify the number of a register to which to output the part data ID assigned to the pushed part data.

IPDEL.PC

Deletes the specified part data from a parts list. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the ID of part data to be deleted from the parts list.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Successfully deleted part data.

1: Failed to delete part data because part data having the specified ID was not found.

999: Failed to delete part data due to an alarm other than the above (the target part data was not found).

IPPOP.PC

Places the specified part data in the popped state. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the part data ID of part data to be popped.

Argument 3:

Specify a pop flag. Specify either of the following values:

- 1: Places part data in the popped state.
- 0: Places part data in the not popped state.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

- 0: Successfully popped part data.
- 1: Failed to pop part data because part data having the specified ID was not found.
- 999: Failed to pop part data due to an alarm other than the above (the target part data was not found).

IPGTLSTPRM.PC

Outputs the value of a parameter such as the push count in a parts list to a register. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the name of a parameter the value of which you want to obtain. You can specify one of the following parameter names:

NUM_PUSH: Specify this name to obtain the push count.

NUM_POP: Specify this name to obtain the pop count.

UPDATE_PUSH: Specify this name to obtain the flag indicating whether to update the push count.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Successfully output the specified parameter to the register.

999: Failed to output the specified parameter to the register.

Argument 4:

Specify the number of a register to which to output the parameter value.

IPSTLSTPRM.PC

Sets the specified value for a parameter such as the push count in a parts list. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the name of a parameter for which you want to set a value. You can specify one of the following parameter names:

NUM PUSH: Specify this name to obtain the push count.

NUM_POP: Specify this name to obtain the pop count.

UPDATE_PUSH: Specify this name to obtain the flag indicating whether to update the push count.

Argument 3:

Specify a value to be set for the parameter.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the

following values is output as the status:

0: Successfully set the specified value for the parameter.

999: Failed to set the specified value for the parameter.

IPGTPRTPRM.PC

Outputs the value of a parameter of part data to a register, vision register, or character register. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the ID of part data.

Argument 3:

Specify the name of a parameter the value of which you want to obtain. You can specify one of the following parameter names:

STATUS: Status

LIFE COUNT: Blacklist count

NUM_ADD: Push count when the part data is pushed in the parts list

NUM_BL: Push count when the part data is set in the blacklist

PRIORITY: Priority

NUM_LAST_FOUND: Push count when the same part as the part data is found

POP_STAT: Flag indicating whether the part data is popped

SCH_RSLT: SEARCH result FINE_RSLT: FINE result

SCH_NAME: SEARCH vision process name FINE_NAME: FINE vision process name

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Successfully output the specified parameter to the register, vision register, or character register.

1: Failed to output the specified parameter to the register, vision register, or character register because part data having the specified ID was not found.

999: Failed to output the specified parameter to the register, vision register, or character register due to an alarm other than the above (the target part data was not found).

Argument 5:

Specify the number of a register, vision register, or character register to which to output the obtained parameter value.

To obtain the value of one of the following parameters, specify a register number:

STATUS: Status

LIFE COUNT: Blacklist count

NUM_ADD: Push count when the part data is pushed in the parts list NUM_BL: Push count when the part data is set in the blacklist

PRIORITY: Priority

NUM_LAST_FOUND: Push count when the same part as the part data is found

POP_STAT: Flag indicating whether the part data is popped

To obtain the value of either of the following parameters, specify a vision register number:

SCH_RSLT: SEARCH result FINE_RSLT: FINE result

To obtain the value of either of the following parameters, specify a character register number:

SCH_NAME: SEARCH vision process name FINE_NAME: FINE vision process name

IPSTPRTPRM.PC

Outputs the value of a parameter of part data to a register, vision register, or character register. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the ID of part data.

Argument 3:

Specify the name of a parameter for which you want to set a value. You can specify one of the following parameter names:

STATUS: Status

LIFE COUNT: Blacklist count

NUM_ADD: Push count when the part data is pushed in the parts list

NUM_BL: Push count when the part data is set in the blacklist

PRIORITY: Priority

NUM_LAST_FOUND: Push count when the same part as the part data is found

FINE_RSLT: FINE result

SCH_NAME: SEARCH vision process name FINE NAME: FINE vision process name

Argument 4: Specify the number of the register, vision register, or character register containing the value to be set for the parameter

To set the specified value for one of the following parameters, specify the number of the register containing the value:

STATUS: Status

LIFE_COUNT: Blacklist count

NUM_ADD: Push count when the part data is pushed in the parts list

NUM_BL: Push count when the part data is set in the blacklist

PRIORITY: Priority

NUM_LAST_FOUND: Push count when the same part as the part data is found

To set the specified value for either of the following parameters, specify the number of the vision register containing the value:

FINE RSLT: FINE result

To set the specified value for either of the following parameters, specify the number of the character register containing the value:

SCH_NAME: SEARCH vision process name FINE NAME: FINE vision process name

Argument 5:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Successfully set the specified value for the parameter.

1: Failed to set the specified value for the parameter because part data having the specified ID was not found.

999: Failed to set the specified value for the parameter due to an alarm other than the above (the target part data was not found).

IPFNDPOS.PC

Searches a range from the specified position for part data and outputs the ID of the part data. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the number of a position register containing position data. Part data is found when the distance (dist(pos, found_pos)) between this position (pos) and part data found position (found_pos) is within the range (dist_min \leq dist(pos, part_pos) \leq dist_max).

Argument 3:

Specify a direction whose value is to be used to calculate dist(pos, found_pos) above. Specify one of the following items:

X: Uses the X-direction element to calculate the distance.

Y: Uses the Y-direction element to calculate the distance.

Z: Uses the Z-direction element to calculate the distance.

XY: Uses the XY-direction element to calculate the distance.

XZ: Uses the XZ-direction element to calculate the distance.

YZ: Uses the YZ-direction element to calculate the distance.

XYZ: Uses the XYZ-direction element to calculate the distance.

Argument 4:

Specify dist_min above.

Argument 5:

Specify dist_max above.

Argument 6:

Specify part data to be output when multiple part data items satisfying dist_min \leq dist(pos, part_pos) \leq dist_max above are found. A value of 1 is specified for the index when the part data nearest dist_min is output. The value specified for the index is incremented each time part data is output in ascending order of closeness to dist_min.

Argument 7:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in searching for part data satisfying the relevant condition.

1: Failed to search for part data because there was no part data satisfying the condition within the specified range.

999: Alarm other than the above

Argument 8:

Specify the number of a register to which to output the ID of the found part data.

Argument 9:

Specify the number of a register to which to output the distance between the output part data and position set in the position register specified for argument 2.

IPFNDPUSH.PC

Searches for part data whose push count is within the specified range when it is added to the parts list and outputs the ID of the part data. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Parameter for determining the part search range. The KAREL program searches for part data whose push count was between the value specified for argument 2 and the value specified for argument 3 when it was added to the parts list.

Argument 3:

Parameter for determining the part search range. The KAREL program searches for part data whose push count was between the value specified for argument 2 and the value specified for argument 3 when it was added to the parts list.

Argument 4:

Specify part data to be output when multiple part data items satisfying the condition specified for arguments 2 and 3 above are found. A value of 1 is specified for the index when the part data whose push count nearest to the push count specified for argument 2 is output. The value specified for the index is incremented each time part data is output in ascending order of closeness to the push count specified for argument 2.

Argument 5:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in searching for part data satisfying the relevant condition.

1: Failed to search for part data because there was no part data satisfying the condition within the specified range.

999: Alarm other than the above

Argument 6:

Specify the number of a register to which to output the ID of the found part data.

Argument 7:

Specify the number of a register to which to output the push count when the output part data is added to the parts list.

IPFNDPRI.PC

Searches for part data with high priority and outputs the ID of the part data. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify the priority order of part data to be output. A value of 1 is specified for the index when the part data with the highest priority in the parts list is output. The value specified for the index is incremented each time part data is output in descending order of priority.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in searching for part data satisfying the relevant condition.

1: Failed to search for part data because there was no part data satisfying the condition within the specified range.

999: Alarm other than the above

Argument 4:

Specify the number of a register to which to output the ID of the found part data.

Argument 5:

Specify the number of a register to which to output the priority of the output part data.

IPFNDVP.PC

Searches for part data whose SEARCH vision process name is the specified vision process name and outputs the ID of the part data. This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List.

Argument 2:

Specify a vision process name for searching for part data.

Argument 3:

Specify the priority order of part data to be output when there are multiple part data items with the vision process name specified for argument 2. A value of 1 is specified for the index when the following part data is output. The SEARCH vision process in the parts list containing the part data is the vision process name specified for argument 2 and the part data has the highest priority. The value specified for the index is incremented each time part data is output in descending order of priority.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in searching for part data satisfying the relevant condition.

1: Failed to search for part data because there was no part data satisfying the condition within the specified range.

999: Alarm other than the above

Argument 5:

Specify the number of a register to which to output the ID of the found part data.

IPCLRARPOS.PC

Use this KAREL program only when using the Search Area Restriction Tool. This KAREL program initializes the list of positions set as the search area provided for each parts list (search area list). This program requires the following arguments.

Argument 1:

Specify the index number of the Parts List. When a value of 0 is specified, the KAREL program initializes the search area lists for all parts lists.

IPSETARPOS.PC

Use this KAREL program only when using the Search Area Restriction Tool. This KAREL program sets the found position of the specified part data or position stored in a position register to the search area list.

Argument 1:

Specify a type of position to be set. You can specify one of the following values:

- 1: Sets the found position of picked part data.
- 2: Sets the found position of part data added to the blacklist.
- 3: Sets the position stored in the specified position register.

Argument 2:

When specifying 1 or 2 for argument 1, specify the number of the register containing the ID of picked part data or part data set in the blacklist. When specifying 3 for argument 1, specify the number of the position register containing a position you want to set for the search area.

Argument 3:

Specify a search area list in which to set the obtained position. Each parts list has a search area list. So, specify the number of a parts list.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

- 0: Successfully set the specified position as the search area
- 1: Failed to set the specified position as the search area

Argument 5:

When specifying 3 for argument 1 to use a position register for search area restriction, specify the user frame number of the coordinate system indicating the position stored in the position register. When specifying 1 or 2 for argument 1, do not enter argument 5.

Advanced Setup

- 1 BIN PICKING CONFIG
- 2 CUSTOMIZATION

1 BIN PICKING CONFIG

The bin picking configuration function on the teach panel is used to set up the configuration of the interference avoidance function and parts list managers. Press the [MENU] key and select [iRVision] \rightarrow [Bin Picking Cfg] to display the main screen for the bin picking configuration.



The following items appear on the main screen for interference avoidance configuration.

[Interference Avoidance Configuration]

Place the cursor on [Interference Avoidance Configuration] and press the [DETAIL]. The Interference Avoidance Configuration screen appears.

[Parts List Manager Configuration]

Place the cursor on [Parts List Manager Configuration] and press the [DETAIL]. The Parts List Manager Configuration screen appears.

1. BIN PICKING CONFIG Advanced Setup

1.1 INTERFERENCE AVOIDANCE CONFIGURATION

The interference avoidance configuration screen allows you to change the maximum number of interference avoidance data that can be created. The robot controller must be power cycled to enable the values of items changed here.



The following items appear on the setup screen for interference avoidance configuration.

[Num. Of Interference Setup(System)]

Specify the maximum number of interference avoidance data (system).

[Num. Of Container]

Specify the maximum number of container objects to be set in interference avoidance data (system).

[Num. Of Fixed Object]

Specify the maximum number of fixed objects that interference avoidance data (system) can have. Note that this is not the number of the fixed objects that can be created for each system data, but the total number of the fixed objects that can be created for all system data.

[Num. Of Interference Setup(Robot)]

Specify the maximum number of interference avoidance data (robot).

[Num. Of Tool Object]

Specify the maximum number of tool objects that interference avoidance data (robot) can have. Note that this is not the number of tool objects that can be created for each robot, but the total number of the tool objects that can be created for all robot data.

[Num. Of Interference Setup(Cond.)]

Specify the maximum number of interference avoidance data (condition).

[Num. Of IA Results]

Specify the maximum number of avoidance results to be output from the interference avoidance calculation. If you change the number of output interference avoidance results, the interference avoidance position does not need to be recalculated each time the FINE vision process or part picking is executed. The processing may take slightly longer, however, because multiple interference avoidance results are calculated every time.

[Use Area under 3D Map to Be Avoided]

Determine whether or not to restrict the use of the area below the 3D map for interference avoidance.

[Update IA 4D Graphics At Run Time]

Determine whether to update the 4D interference avoidance data at process run time.

1.2 PARTS LIST MANAGER CONFIGURATION

The setup screen for the parts list manager configuration allows you to change the maximum number of parts lists that can be created. The robot controller must be power cycled to enable the values of items changed here.



The following items appear on the setup screen for parts list manager configuration.

[Num. Of Parts List]

Specify the number of parts lists.

[Num. Of SEARCH Vision Process]

Specify the number of SEARCH vision processes that the parts list manager for the parts list can set for a SEARCH vision process list.

[Num. Of FINE Vision Process]

Specify the number of FINE vision processes that the parts list manager for the parts list can set for a FINE vision process list.

[Num. Of FINE Position]

Specify the number of FINE positions that the parts list manager for the parts list can set for a FINE position list.

1. BIN PICKING CONFIG Advanced Setup

[Num. Of PICK Position]

Specify the number of PICK positions that the parts list manager for the parts list can set for a PICK position list.

[Update PM 4D Graphics At Run Time]

Specify whether to update the 4D parts list data at process run time.

Advanced Setup 2. CUSTOMIZATION

2 CUSTOMIZATION

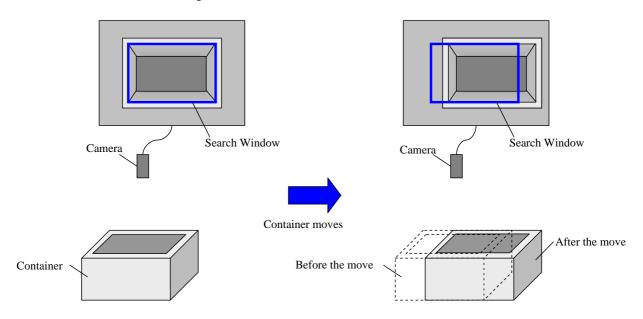
This chapter describes how to further customize the bin picking system that is described earlier in this manual.

2.1 HOW TO CUSTOMIZE WHEN THE CONTAINER POSITION MOVES

In a bin-picking system, due to a reason that the container will not surely be positioned according to the mechanism or that it is positioned to a certain degree but the clearance is relatively large, the container installation position may change each time when it is replaced, causing the following problems.

- A misjudgment frequently occurs with the interference avoidance function. The container object set in the system data for interference avoidance memorizes the container position and size based on three points in the reference user frame set in the system data. For this reason, if the container installation position changes, the memorized position of the container object and the actual position of the container will not match, resulting in a misjudgment on interference.
- The search window cannot be set correctly.

 The part search window set by the SEARCH vision process is normally set along the internal wall of a container in which the part is present. However, if the container installation position moves, the search window will not be set correctly along the internal wall of the container, resulting in parts that cannot be found (see the figure below).



Some parts cannot be detected because the container position has moved

If this is the case, use a function that automatically moves the container object and search window. This function uses the found result of a vision process for finding the container installation position to internally move them.

First, create and set up the vision process that detects the container position.

B-83914EN-6/02 201

2

2. CUSTOMIZATION Advanced Setup

Creating and setting a container detection vision process

On the [Vision Setup] screen of *i*RVision, create and set a vision process for finding a container. When the optical axis of the camera installed in the upper part of the container is inclined with respect to the horizontal plane of the container, as in the bin picking system with a 3D area sensor, it is recommended to use the '2-D Multi-View Vision Process'. For information about teaching the '2-D Multi-View Vision Process', refer to the description of 2-D Multi-View Vision Process in the "*i*RVision OPERATOR'S MANUAL (Reference) B-83914EN".

Changing TP Programs

This section describes how to make changes to the TP program described in "Basic Setup Procedures: 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR" to create a TP program that uses the container detection result for bin picking. You can use similar approaches to customize the TP program for other bin picking systems.

First, in addition to the registers used in the TP program described in "Basic Setup Procedures: 1.8 TEACHING TP PROGRAM", the following new registers are used:

New Registers to Be Used

R [15]	Maximum number of retries allowed for container detection
R [16]	Number of retries made for container detection

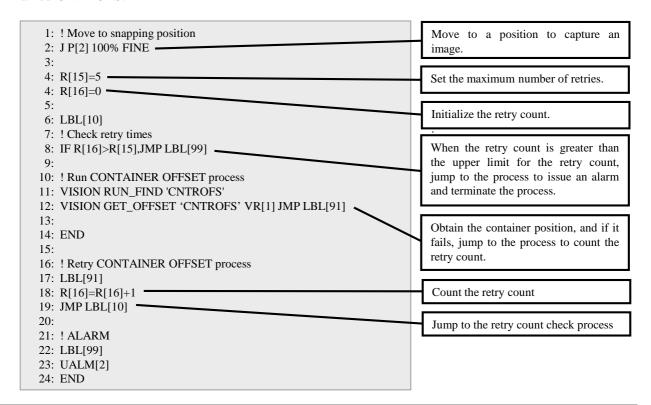
Also, the following vision register is newly used:

New Vision Register to Be Used

VR [1] Vision register that stores the container detection result	
---	--

BIN FIND CONTAINER.TP

Add a TP program that detects the container. If the program fails to get the offset data, it retries the number of times that is set as the value in R [15]. If the number of retries exceeds the value set in R [15], a user alarm is output. In the TP program shown below, the vision process that detects the container is named CNTROFS.



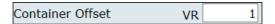
Advanced Setup 2. CUSTOMIZATION

BIN PICKING.TP

In the TP program V_3DA_BP.TP described in "Basic Setup Procedures: 1.8 TEACHING TP PROGRAM", change the part in bold below.

2.1.1 Moving the Container Object in the Interference Setup Data According to the Amount of Container Travel

Open the edit screen to show the interference avoidance data (system). Enter the number of the vision register that stores the result of the container detection vision process described earlier in the [VR] for [Container Offset] in the setting item area.



In the tree view of the edit screen for interference setup data (system), select the object to move along with the container. Check the [Shift Object Pos.] check box for the setting item area.

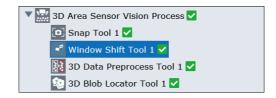


2.1.2 Shifting the Search Window According to the Amount of Container Travel

This section describes how to shift the search window for SEARCH according to the amount of the container travel (using the '3D Area Sensor Vision Process').

Adding and Teaching the Window Shift Tool

Add the Window Shift Tool to the '3D Area Sensor Vision Process'.



In the tree view of the edit screen for the vision program, select [Window Shift Tool], and select [Other VP Result] from the [Input Data Type] drop-down box in the setting item area. Enter the number of the

2. CUSTOMIZATION Advanced Setup

vision register that stores the result of the container detection vision process in the [VR to Use] text box displayed by selecting [Other VP].



Teaching the 3D Data Preprocess Tool and 3D Locator Tools

After executing the container detection vision process from the TP program once, get the vision offset and store the result in the vision register. Then, teach the container shape on the edit screen for the 3D Data Preprocess Tool. When the Search window is used by 3D Locator Tools such as the 3D Peak Locator Tool, re-teach the Search window. For details on how to set up, refer to the description for the command tool in "iRVision OPERATOR'S MANUAL (Reference) B-83914EN".

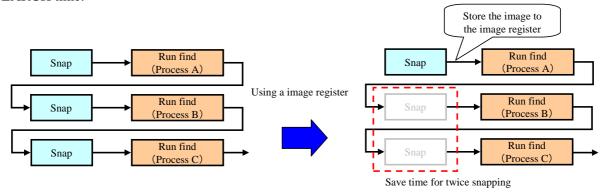
2.2 HOW TO CUSTOMIZE TO REDUCE PROCESSING TIME FOR SEARCH

This section describes how to reduce the processing time for SEARCH.

2.2.1 Using an Image Register

An image register is an area where captured images are temporarily stored. By saving the data necessary for detection, such as the captured image and the robot position at the time of image capture in the image register, image capture and detection can be performed independently.

In a TP program where multiple SEARCH vision processes are set and the vision processes are switched until a part is detected, as shown on the left side of the following figure, an image is captured each time a vision process is executed, regardless of whether the status of the part has changed, thus making the time it takes to capture images longer than necessary. By storing the image captured before executing the first vision process in the image register and using the image in the image register for the subsequent vision processes, the need to capture an image for each vision process is eliminated, which leads to a shorter SEARCH time.



Using an image register to shorten processing time

The method to achieve customization for a bin picking system using an image register is described below.

Creating an Image Register

Set the number of necessary image registers in the system variable \$VISION_CFG.\$NUM_IMREGS. The default value is 1. Up to 10 image registers can be created.

Also, set the size of the image register in the system variable \$VISION_CFG.\$IMREG_SIZE. The default value is 1,500,000 bytes. If more than one image register is required, set \$VISION_CFG.\$IMREG_SIZE to a value that is equal to 1500000 x [Number of Image Registers].

Advanced Setup 2. CUSTOMIZATION

If you change the value of the system variables \$VISION_CFG.\$NUM_IMREGS / \$VISION CFG.\$IMREG SIZE, cycle power on the controller to recreate image registers.

Setting up the Parts List Manager

Use the parts list manager to display the edit screen for the SEARCH vision process list. Select the number of created image register used to execute SEARCH from the [Img. Reg] drop-down box



Changing the TP Program

This section describes how to make changes to the TP program described in "Basic Setup Procedures: 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR" to create a TP program that uses image registers for SEARCH.

First, in addition to the registers used in the sample TP program described in "Basic Setup Procedures: 1.8 TEACHING TP PROGRAM", the following new registers are used:

R [5] SEARCH list ID of the Parts List Manager

B-83914EN-6/02 205

2

2. CUSTOMIZATION Advanced Setup

V 3DA BP.TP

In the TP program V_3DA_BP.TP described in "Basic Setup Procedures: 1.8 TEACHING TP PROGRAM", change the part in bold below.

```
1: !The register numbers and
 2: !position register numbers below
 3: !should be changed according to
 4: !those set by CMT_3DA_BP.TP.
 6: UFRAME_NUM=1
 7: UTOOL_NUM=1
 8: CALL BINPICK_CLEAR("Parts List ID"=1)
10: !SEARCH
11: LBL[1]
12: L P[1:Search] 2000mm/sec FINE
                                                                         Add the instruction to snap an image
13: CALL BINPICK_ACQUIRE3DMAP("3D Area Sensor"=
                                                                         and store it in the image register.
    'V_3DA_CAM')
14:
15: CALL IRVSNAP('V_3DA_SAMPLE', 1)
                                                                         Add the instruction to set the ID
16: R[5]=1
                                                                         number of SEARCH vision process
                                                                         which runs in the first.
17: LBL[10]
18: CALL BINPICK_SEARCH(1,R[5],10) ~
19: IF R[10]<>0,JMP LBL[11]
                                                                         Change to specify the ID number of
20: JMP LBL[2]
                                                                         the SEARCH vision process by R[5].
21:
22: LBL[11]
                                                                        If the SEARCH vision process finds no parts, switch to
23: SELECT R[5]=1,JMP LBL[12] -
                                                                         another SEARCH vision process set in the SEARCH
24:
       =2,JMP LBL[13]
25:
      ELSE,JMP LBL[999]
26:
                                                                        If the vision process set to Index 1 of
27: LBL[12]
                                                                        the SEARCH VP List finds no parts,
28: R[5]=2
                                                                        execute the vision process set to Index
29: JMP LBL[10]
                                                                        2 of the SEARCH VP List.
30:
31: LBL[13]
                                                                        If the vision process set to Index 2 of
32: R[5]=3
                                                                        the SEARCH VP List finds no parts,
33: JMP LBL[10]
                                                                        execute the vision process set to Index
34:
                                                                        3 of the SEARCH VP List.
35: !POP
36: LBL[2]
37: CALL BINPICK_POP("Parts List ID"=1,
    "Status R"=11,"Model ID R"=12)
38: IF R[11:Pop Status]<>0,JMP LBL[1]
```

Advanced Setup 2. CUSTOMIZATION

2.3 HOW TO CUSTOMIZE TO EXECUTE THE SEARCH PROCESS IN THE BACKGROUND PROCESS

The TP program may waste time by stopping the robot at each SEARCH process. By executing SEARCH for the next part to be picked while placing the held part, efficient bin picking can be performed. Specifically for the bin picking system with the 3D Area Sensor, which requires a considerable amount of time to acquire the 3D map, the cycle time can be reduced considerably by making calculations in the background. Use as examples the TP programs that execute SEARCH and other processes on the system that are described in "Basic Setup Procedures: 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR" and "Basic Setup Procedures: 2 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR" for explanation. You can use similar approaches to execute SEARCH and other processes in the background for other bin picking systems.

2.3.1 Bin Picking System With 3D Area Sensor

This section describes sample TP programs that execute SEARCH and other processes in the background on the system that is described in "Basic Setup Procedures: 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR".

The sample TP program is pre-installed in the bin picking system. You can save the labor of setting up by editing the sample TP program according to each actual application.

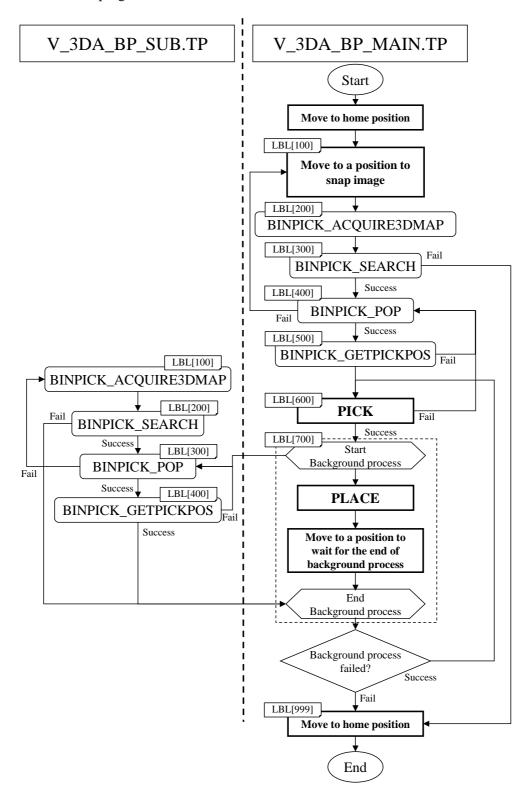
If parts are to be picked from multiple containers, refer to "Advanced Setup: 2.4 HOW TO CUSTOMIZE BIN PICKING SYSTEM WITH MULTIPLE CONTAINERS".

B-83914EN-6/02 207

2

2.3.1.1 Process Flow

The flow chart of the TP programs described here is as follows:



As shown in the above figure, the following two programs are mainly used for processes. The main program V_3DA_MAIN.TP is involved in the robot motion and the sub program V_3DA_SUB.TP makes calculations in the background. The sub program is called just before the placing operation after success in picking. During the placing operation, it performs operations for POP or getting PICK position in the

background, and also performs operations for acquiring 3D map and SEARCH if required. Parallel processes are executed only during the placing operation because the main program waits for the sub program to be completed when the placing operation is done.

Also, right after the system starts up or if picking fails, no placing operation occurs, so SEARCH and other processes are not executed in the background and processes from 3D map acquisition to PICK position acquisition are performed by the main program.

2.3.1.2 Register setting table

The TP programs explained here use the following registers, position registers, tool frame, and user frame.

Register to Be Used

R [1]	Register that represents the status of the system. Setting a non-zero value causes
	the system to end. The value indicates one of the following states.
	0: Normal
	1: Cannot detect a part.
R [2]	Register that represents whether the gripper is holding a part. The value
	indicates one of the following states.
	0: Not Holding a part.
	1: Holding a part.
R [3]	Register that represents whether the sub program is completed. The value
	indicates one of the following states.
	0: Not completed.
	1: Completed.
R [4]	The status of SEARCH vision process
	0: SUCCESS (More than one new pushed data set exists)
	1: FAIL (No new pushed data set exists)
R [5]	The status of POP
	0: SUCCESS
	1: FAIL (No part data that can be popped)
R [6]	Model ID of the popped part data
R [7]	Status of the get PICK position process. One of the following values is set:
	0: SUCCESS
	12: Failed to get an interference avoidance position at the PICK position
	13: Failed to get an interference avoidance position at the approach position
R [8]	The status that represents whether the robot is within the camera's field of view.
	The value indicates one of the following states.
	0: The robot is within the camera's field of view.
	1: The robot is outside of the camera's field of view.

Position Register to Be Used

PR [20]	PICK position
PR [21]	Result of interference avoidance for the part pick position (tool offset value)
PR [22]	This is the Approach position.
PR [23]	Set the tool offset value from the PICK position used for approach position
	calculation.
	Example: (0.0, 0.0, 100.0, 0.0, 0.0, 0.0) in the cartesian or matrix format.

Tool frame to Be Used

	UTOOL [1]	The TCP of the gripper
--	-----------	------------------------

User frame to Be Used

Oser frame to be osed	
UFRAME [1]	Application frame

2.3.1.3 Batch input of register comments

This system has a pre-installed sample program. By entering comments to registers and other elements used in this sample program in advance, you can check operation and modify your program easily. Although manually setting comments takes time, it will save on the labor of performing the operation.

1 Select [CMT_3DA_BP_ADVANCED.TP] on the program list screen and execute it.



2 Check that the comments are entered as follows on the register list screen and the position register list screen.

Registers

R [1]	System status
R [2]	Gripper holding the part
R [3]	Subprogram status
R [4]	Detection status
R [5]	Pop status
R [6]	Pop Model ID
R [7]	Pick status
R [8]	Robot in FOV

Position registers

PR [20]	Pick
PR [21]	Pick interference offset
PR [22]	Pick approach
PR [23]	Pick approach offset

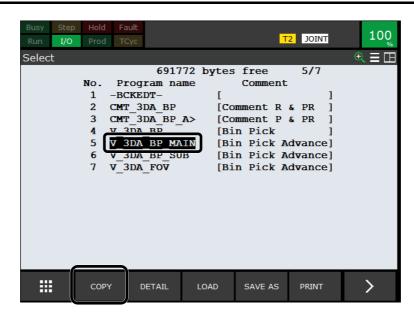
2.3.1.4 Copying TP programs

Since editing the original of the sample TP program is prohibited, copy and edit the sample TP program.

1 Select [V_3DA_BP_MAIN.TP] and click [COPY] on the program list screen.

MEMO

Copy the subprogram (V_3DA_BP_SUB.TP) in the same way as is done for V_3DA_BP_MAIN.TP.



2 Edit the program name and click [OK].

2.3.1.5 Editing the main program

Edit the TP program copied in "Advanced Setup: 2.3.1.4 Copying TP programs".

1 Teach each position in the TP program.

Positions

P[1: Home]	The robot's home position. Teach a position where the robot will not come
	into the sensor's field of view.
P[11: Search]	The robot's waiting position when SEARCH is being executed. It may be
	the same position as the home position.
P[61: Pick Approach]	The approach position when picking the part.
P[62: Pick Retract]	The retract position after picking the part. It may be the same position as
	the approach position when picking the part.
P[63]	A relay position when moving from the retract position after picking the
	part to the approach position when placing the part.
P[71: Place Approach]	The approach position when placing the part. In this program, a flag
	indicating that the robot is out of the sensor's field of view is set 0.5
	seconds after the robot reaches this position. Therefore, teach a position
	where the robot will not come into the sensor's field of view.
P[72: Place Approach]	The approach position when placing the part. Set a point that is closer to
	the position where the part is placed than P[71].
P[73: Place]	The placement position.

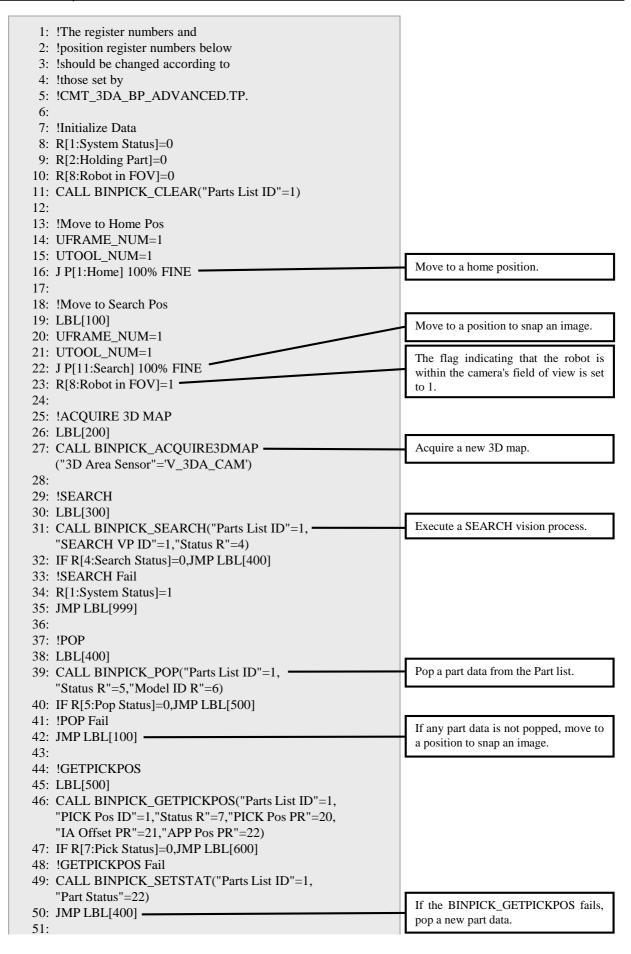
Add part picking and placing instructions.

For the CALL instruction in L64, specify the instruction to place and pick up the part with the gripper.

For the CALL instruction in L89, specify the instruction to place the part with the gripper.

V 3DA BP MAIN.TP

This is the main program for bin picking. Note that since editing V_3DA_BP_MAIN.TP is prohibited, you will actually be editing the TP program copied from V_3DA_BP_MAIN.TP in "Advanced Setup: 2.3.1.4 Copying TP programs". There are lines to call subprograms V_3DA_BP_SUB.TP and V_3DA_FOV.TP from V_3DA_BP_MAIN.TP, but note that copied subprograms must be called here as well.



52: !PICK	
53: LBL[600]	
54: UFRAME_NUM=1	
55: UTOOL_NUM=1	The flag indicating that the robot is
56: R[8:Robot in FOV]=0	within the camera's field of view is set
57:	to 0.
58: L P[61:Pick Approach] 500mm/sec CNT50	
59: !Move to Pick Pos	Move to a above position of the
60: L PR[22:Pick App.] 500mm/sec CNT50	container.
61: L PR[20:Pick] 200mm/sec FINE	container.
62: !Insert program instructions	Move to the position to pick up the
63: !to grasp the part.	part.
64: CALL	r ····
65: L PR[22:Pick App.] 500mm/sec CNT50	
66: L P[62:Pick Retract] 300mm/sec FINE INC	
67: !Insert program instructions	
68: !whether grasp succeeds or not.	
69: CALL	Check if the robot holds the parts.
70:	
71: IF R[2:Holding Part]=1,JMP LBL[610]	
72: !PICK Fail	
73: CALL BINPICK_SETSTAT("Parts List ID"=1,	
"Part Status"=21)	
74: JMP LBL[400] -	If the robot does not hold the part, pop
75: !PICK Success	a next part data.
76: LBL[610]	
77: CALL BINPICK_SETSTAT("Parts List ID"=1,	Move to a above position of the
"Part Status"=20)	container.
78: L P[63] 500mm/sec CNT100	Start the background process to get a
79:	next PICK position.
80: !Start Background Calc. and PLACE	Change V_3DA_BP_SUB to the
81: LBL[700]	copied TP program.
82: R[3:Bg. Status]=0	
83: RUN V_3DA_BP_SUB	The flag indicating that the robot is
84: J P[71:Place Approach] 100% CNT100	within the camera's field of view is set
TA .50sec,CALL V_3DA_FOV	to 1 after moving to a position that the
85: L P[72:Place Approach] 300mm/sec CNT100	robot is not within the camera's field
86: L P[73:Place] 300mm/sec FINE	of view.
87: !Insert program instructions	
88: !to release the part.	
89: CALL	
90:	Mayo to the medicine to the d
91: L P[72:Place Approach] 300mm/sec CNT100	Move to the position to pick up the
92: L P[71:Place Approach] 300mm/sec CNT100	part.
93: WAIT R[3:Bg. Status]=1	
94: !End Background Calc.	Wait for the end of background
95:	process.
96: IF R[1:System Status]=1,JMP LBL[999]	
97: JMP LBL[600]	
98:	
99: LBL[999]	
100: UFRAME_NUM=1	
101: UTOOL_NUM=1	
102: J P[1:Home] 100% FINE	

Advanced Setup 2. CUSTOMIZATION

2.3.1.6 Checking subprograms

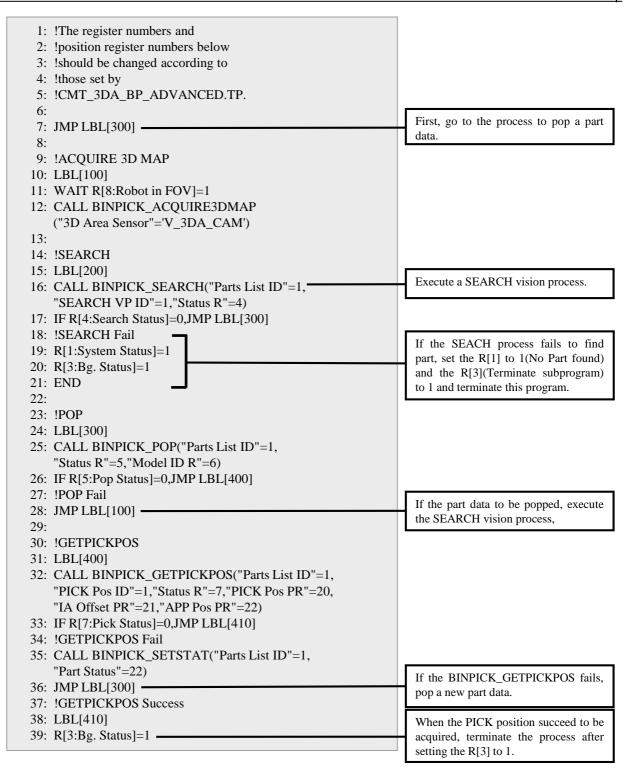
Check the content of the subprograms. When you have changed the register numbers to be used, etc., edit the program accordingly.

V_3DA_BP_SUB.TP

This is the sub program to perform bin picking. It performs POP, PICK position acquisition, and if required, 3D map acquisition or SEARCH. Note that since editing V_3DA_BP_SUB.TP is prohibited, you will actually be editing the TP program copied from V_3DA_BP_SUB.TP in "Advanced Setup: 2.3.1.4 Copying TP programs".

B-83914EN-6/02 215

2



V 3DA FOV.TP

This program sets the flag indicating that the robot is outside of the camera's field of view to 1. To ensure that the robot is out of the camera's field of view, the sub program waits for the process to acquire a 3D map while 0 is set to the R [8].

If there is a problem in the acquired 3D map and it may be due to the robot being in the camera's field of view, adjust the time of the TA instructions or the robot position to call this program in the main program. Note that since editing V_3DA_FOV.TP is prohibited, you must edit the TP program copied from V_3DA_BP_FOV.TP in "Advanced Setup: 2.3.1.4 Copying TP programs" if you need to change the register numbers.

Advanced Setup 2. CUSTOMIZATION

2.3.1.7 Checking operation

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

• Place a part near the reference position, detect it, and check that it can be picked up accurately. If the accuracy of compensation is low, retry the reference position setting.

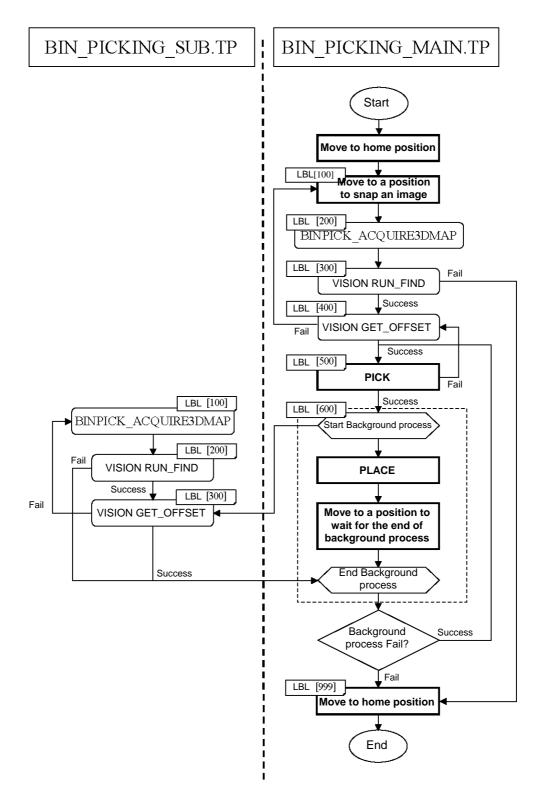
- Move the part in the X direction or Y direction without rotation, find it and check that it can be picked up accurately.
- Rotate the part, find it and check that it can be picked up accurately.
- Find the part by placing and rotating it differently from the reference position and check that it can be picked up accurately.
- Start with lower override of the robot to check that the logic of the program and the motion of the robot are correct. Next, increase the override to check that the robot can operate continuously.

2.3.2 Fixed Frame Offset System With 3D Area Sensor

This section describes sample TP programs that execute SEARCH and other processes in the background on the system that is described in "Basic Setup Procedures: 2 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR".

2.3.2.1 Process Flow

The flow chart of the TP programs described here is as follows:



As shown in the above figure, the following two programs are mainly used for processes. The main program BIN_PICKING_MAIN.TP is involved in the robot motion and the sub program BIN_PICKING_SUB.TP makes calculations in the background. The sub program is called just before the placing operation after success in picking. During the placing operation, it performs operations in the background such as offset acquisition, 3D map acquisition, and vision detection if required. Parallel processes are executed only during the placing operation because the main program waits for the sub program to be completed when the placing operation is done.

Advanced Setup 2. CUSTOMIZATION

Also, right after the system starts up or if picking fails, no placing operation occurs, so vision detection and other processes are not executed by the sub program and processes from 3D map acquisition to offset acquisition are performed by the main program.

2.3.2.2 Register setting table

The TP programs explained here use the following registers, position registers, vision registers, tool frame, and user frame.

R [1]	Register that represents the status of the system. Setting a non-zero value causes the system to end. The value indicates one of the following states. 0: Normal
	1: Cannot detect a part.
R [2]	Register that represents whether the gripper is holding a part. The value indicates one of the following states.
	0: Not holding a part.
	1: Holding a part.
R [3]	Register that represents whether the sub program is completed. The value
	indicates one of the following states.
	0: Not completed.
	1: Completed.
R [4]	The number of results found by a SEARCH vision process
R [11]	The status that represents whether the robot is within the camera's field of view.
	The value indicates one of the following states.
	0: The robot is within the camera's field of view
	1: The robot is outside of the camera's field of view.

Vision register to be used

VR [1]	Register that stores the offset data for SEARCH vision process	
Tool frame to Be Used		
LITOOL [1]	The TCD of the gripper	

UTOOL [1]	The TCP of the gripper

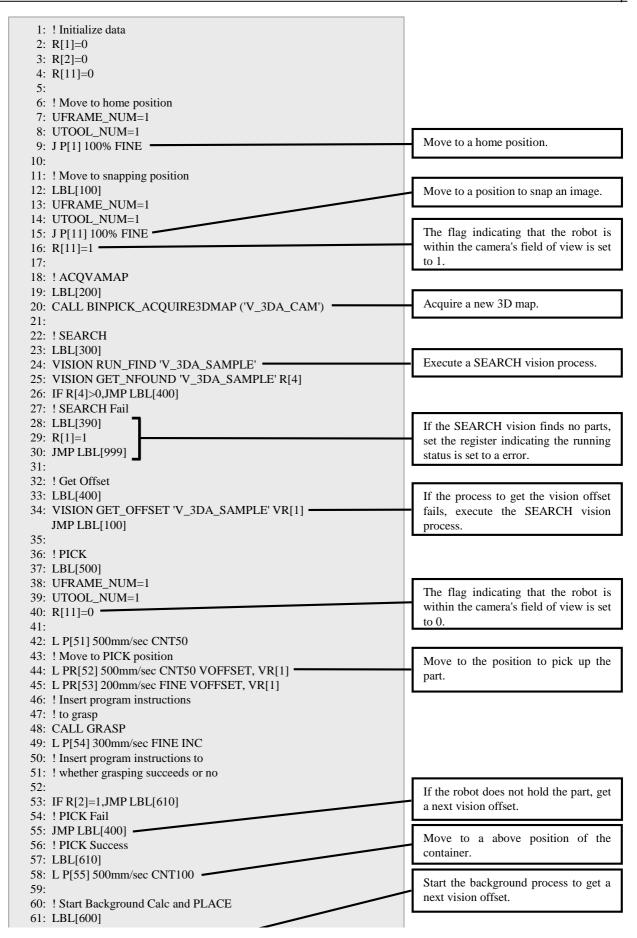
	User frame to Be Used
UFRAME [1]	Application frame

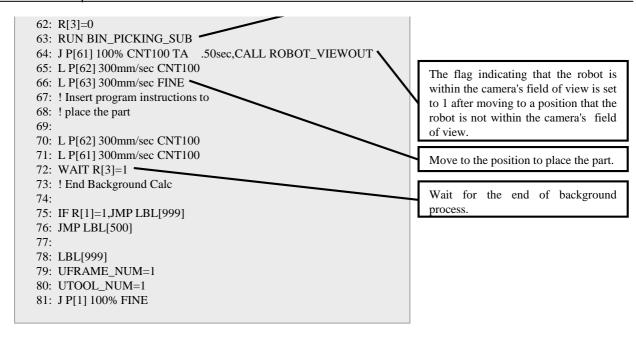
2.3.2.3 Creating and teaching TP program

Create a TP program and teach positions. Although the pre-installed samples [V_3DA_CAM] and [V_3DA_SAMPLE] are used for sensor data and vision process, replace them with others as necessary.

BIN PICKING MAIN.TP

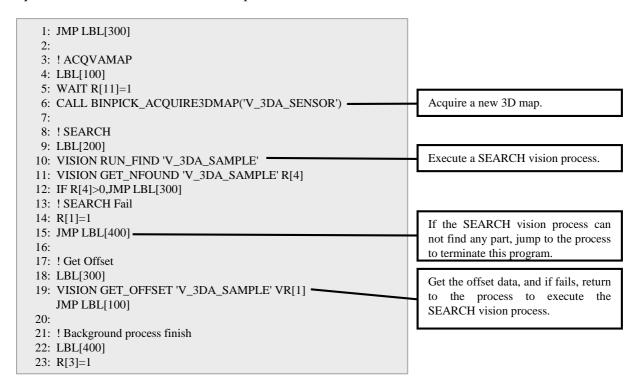
This is the main program for fixing 3D positions.





BIN_PICKING_SUB.TP

This is the sub program for fixing 3D positions. It acquires the offset in the background. If it fails to acquire the offset, it executes the vision process. It is called from BIN_PICKING_MAIN.TP.



ROBOT VIEWOUT.TP

This program sets the flag indicating that the robot is outside of the camera's field of view to 1. This program is called by the TA instruction just after the robot moves out of the camera's field of view. To ensure that the robot is out of the camera's field of view, the sub program waits for R [11] to be set to 1 before acquiring a 3D map. If there is a problem in the acquired 3D map and it may be due to the robot being in the camera's field of view, adjust the time of the TA instructions or the robot position to call this program in the main program.



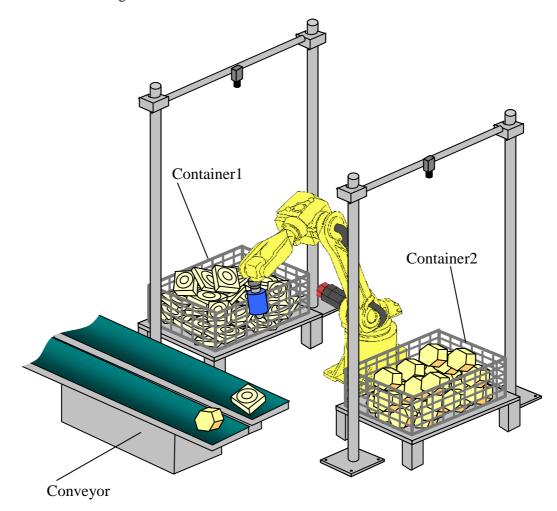
2.3.2.4 Checking operation

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

- Place a part near the reference position, detect it, and check that it can be picked up accurately. If the accuracy of compensation is low, retry the reference position setting.
- Move the part in the X direction or Y direction without rotation, find it and check that it can be picked up accurately.
- Rotate the part, find it and check that it can be picked up accurately.
- Find the part by placing and rotating it differently from the reference position and check that it can be picked up accurately.
- Start with lower override of the robot to check that the logic of the program and the motion of the robot are correct. Next, increase the override to check that the robot can operate continuously.

2.4 HOW TO CUSTOMIZE BIN PICKING SYSTEM WITH MULTIPLE CONTAINERS

This section describes how to achieve customization for performing bin picking with multiple containers. It describes how to customize the system described in "Basic Setup Procedures: 1 BIN PICKING SYSTEM WITH 3D AREA SENSOR" to create a system that picks parts sequentially from two containers as shown in the figure below:



Sample system configuration that picks parts sequentially from two containers

2.4.1 Preparing a Container

When performing bin picking with multiple containers, provide a separate parts list for each container.

2.4.1.1 Changing the number of parts list

By default, the number of parts lists is 1. To change the number of parts lists, perform the procedure described below. Up to 20 parts lists can be created.

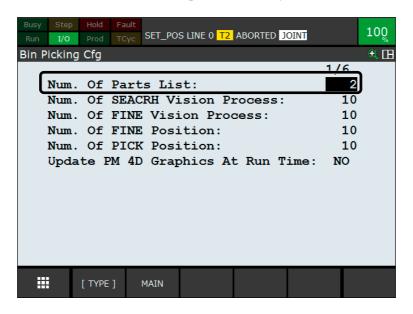
On the teach panel, press the [MENU] key \rightarrow [iRVision] \rightarrow [Bin Picking Cfg] and press the [Enter] key.

The [Bin Picking Cfg] screen appears.

Move the cursor to [Parts List Manager Configuration] and press F2 [DETAIL]. The setup screen for the parts list manager configuration appears.



3 Move the cursor to [Num. Of Parts List] and press the [2] key.



4 Cycle the power to the robot controller.

This enables multiple parts lists to be used.

2.4.1.2 Setting up 3D area sensor data

Set up the 3D Area Sensor installed in the upper part of Container 2. The setup method is the same as for Container 1.

2.4.1.3 Setup of interference avoidance data

Create the interference avoidance data (system) for Container 2 and set it up.

Advanced Setup 2. CUSTOMIZATION

2.4.1.4 Search vision process setup

Create the '3D Area Sensor Vision Process' and set it up so that the parts inside Container 2 can be detected.

2.4.1.5 Setup of parts list manager

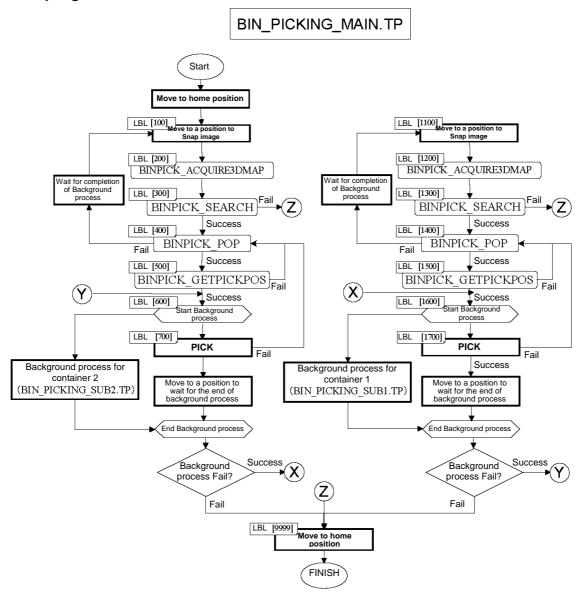
Set up parts list 2 in Parts List Manager.

Add the created SEARCH vision process to [SEARCH VP List] in Parts List Manager. Set the PICK position for [PICK Position List] in Parts List Manager. When setting the PICK position, select the same user frame number to be used as that for parts list 1.

2.4.2 Process Flow

The flow chart of the TP programs described here is as follows:

Main program

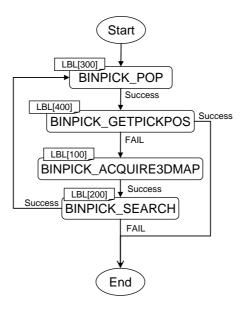


B-83914EN-6/02 225

2

Sub programs for background processes





As can be seen from the figure above, there are the following three major TP programs.

- Main program (BIN_PICKING_MAIN.TP in the figure above)
- Sub program for container 1 (BIN_PICKING_SUB1.TP in the figure above)
- Sub program for container 2 (BIN_PICKING_SUB2.TP in the figure above)

The sub program is called just before the picking operation. For example, during the picking operation on Container 1, it performs POP, PICK position acquisition, and if required, 3D map acquisition or SEARCH.

The main program waits for the sub program to complete processes when:

- The placing operation on the part is completed Next, a part is picked from a container that is not the one from which a part was previously picked.
- The part picking failed Next, a different part is picked from the container where the part picking failed previously.

2.4.3 Register Setting Table

The TP programs explained here use the following registers, position registers, tool frame, and user frame.

Register to Be Used

R [1]	Register that represents the status of the system. Setting a non-zero value causes		
	the system to end. The value indicates one of the following states.		
	0: Normal		
	1: Cannot detect a part.		
R [2]	Register that represents whether the gripper is holding a part. The value		
	indicates one of the following states.		
	0: Not holding a part.		
	1: Holding a part.		

Advanced Setup 2. CUSTOMIZATION

R [3]	Register that represents whether the sub program is completed. The value			
[-]	indicates one of the following states.			
	0: Not completed.			
	1: Completed.			
R [4]	The status of SEARCH vision process for parts list 1			
R [5]	The status of POP for parts list 1			
R [6]	Model ID of the popped part data from parts list 1			
R [7]	Status of the get PICK position process for parts list 1. One of the following			
	values is set:			
	0: SUCCESS			
	12: Failed to get an interference avoidance position at the PICK position			
	13: Failed to get an interference avoidance position at the approach position			
R [8]	The flag indicating that a PICK position calculated by the			
	BIN_PICKING_SUB1 exists. The value indicates one of the following states.			
	0: Does Not Exist			
	1: Exists			
R [104]	The status of SEARCH vision process for parts list 2			
R [105]	The status of POP for parts list 2			
R [106]	Model ID of the popped part data from parts list 2			
R [107]	Status of the get PICK position process for parts list 2. One of the following			
	values is set:			
	0: SUCCESS			
	12: Failed to get an interference avoidance position at the PICK position			
	13: Failed to get an interference avoidance position at the approach position			
R [108]	The flag indicating that a PICK position calculated by BIN_PICKING_SUB2			
	exists. The value indicates one of the following states.			
	0: Does Not Exist			
	1: Exists			

Position Register to Be Used

	Position Register to be used
PR [20]	Parts list 1: Result of interference avoidance for the part pick position
	(avoidance position)
PR [21]	Parts list 1: Result of interference avoidance for the part pick position (tool
	offset value)
PR [22]	Parts list 1: Result of interference avoidance for the approach position
	(avoidance position)
PR [120]	Parts list 2: Result of interference avoidance for the part pick position
	(avoidance position)
PR [121]	Parts list 2: Result of interference avoidance for the part pick position (tool
	offset value)
PR [122]	Parts list 2: Result of interference avoidance for the approach position
	(avoidance position)

Tool frame to Be Used

UTOOL [1] The TCP of the gripper	
----------------------------------	--

User frame to Be Used

UFRAME [1]	Application frame		
[-]			

The Parts List Manager is set as follows.

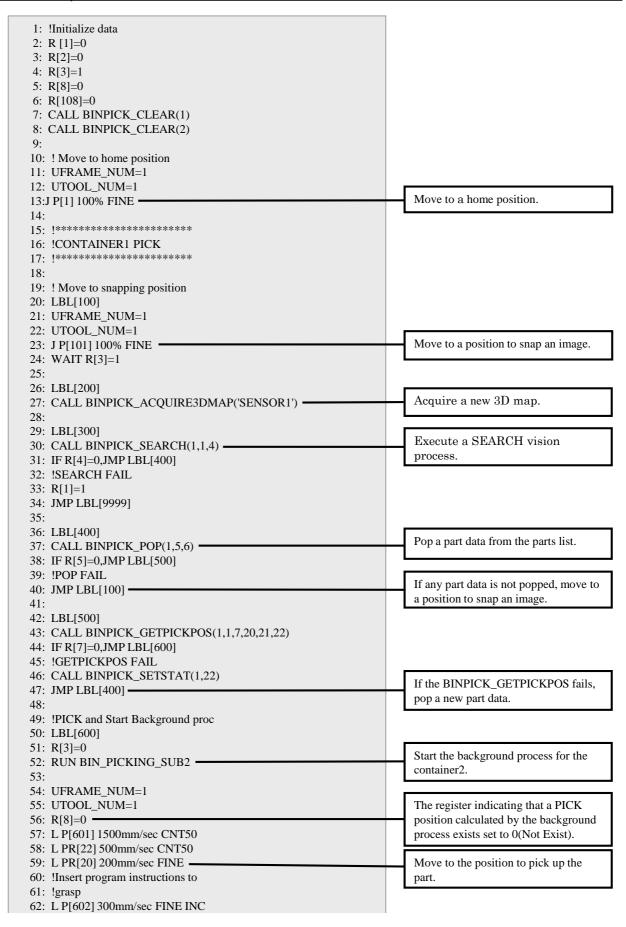
The SEARCH vision process ID of the SEARCH VP List of the Parts List Manager to be used: 1 The PICK position ID of the PICK Position List of the Parts List Manager to be used: 1

2.4.4 Creating and Teaching TP Program

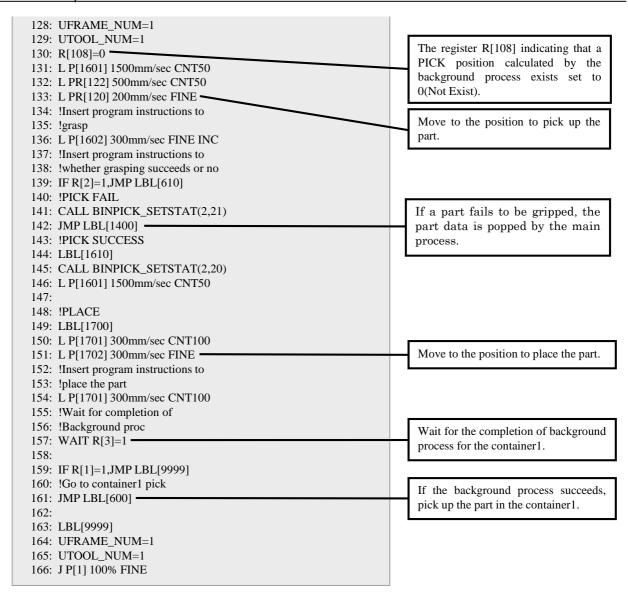
Create a TP program and teach positions. [SENSOR1] and [SENSOR2] are used as the sensor data names.

BIN_PICKING_MAIN.TP

This is the main program for bin picking.

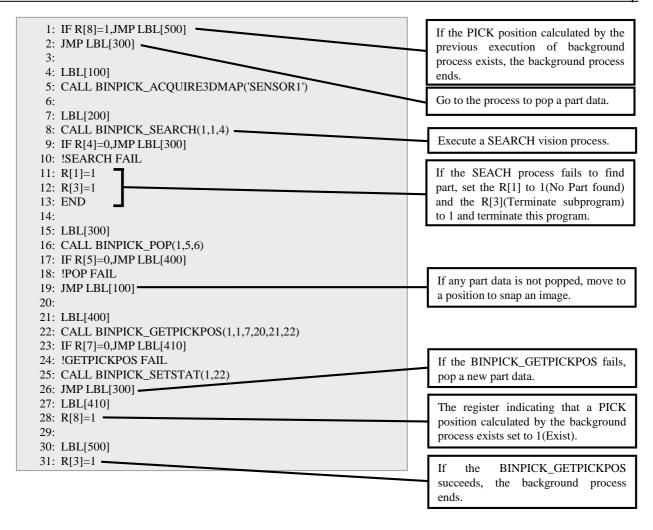


63: !Insert program instructions to 64: !whether grasping succeeds or no 65: IF R[2]=1_JMP LBL[610] 66: !PICK FAIL 67: CALL BINPICK_SETSTAT(1,21) 68: JMP LBL[400] 69: !PICK SUCCESS 70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: !PLACE 75: LBL[700] 76: L P[702] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1_JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	ne part.
65: IF R[2]=I,JMP LBL[610] 66: !PICK FAIL 67: CALL BINPICK_SETSTAT(1,21) 68: JMP LBL[400] 69: !PICK SUCCESS 70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	ne part.
66: PICK FAIL 67: CALL BINPICK_SETSTAT(1,21) 68: JMP LBL[400] 69: PICK SUCCESS 70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: PLACE 75: LBL[700] 76: L P[701] 300mm/sec FINE 77: Insert program instructions to 79: place the part 80: L P[701] 300mm/sec CNT100 81: Wait for completion of 82: Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[999] 86: Go to container2 pick 87: JMP LBL[1600] 88: 89: ************************************	ne part.
67: CALL BINPICK_SETSTAT(1,21) 68: JMP LBL[400] 69: PICK SUCCESS 70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: PLACE 75: LBL[700] 76: L P[701] 300mm/sec FINE 78: Ilnsert program instructions to 79: lplace the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	ne part.
68: JMP LBL[400] 69: !PICK SUCCESS 70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	ne part.
69: JPICK SUCCESS 70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: IPLACE 75: LBL[700] 76: L P[701] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	ne part.
70: LBL[610] 71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
71: CALL BINPICK_SETSTAT(1,20) 72: L P[601] 1500mm/sec CNT50 73: 74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 88: 89: !************************************	eeds,
72: L P[601] 1500mm/sec CNT50 73: 74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
73: 74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
74: !PLACE 75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
75: LBL[700] 76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
76: L P[701] 300mm/sec CNT100 77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
77: L P[702] 300mm/sec FINE 78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
78: !Insert program instructions to 79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
79: !place the part 80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
80: L P[701] 300mm/sec CNT100 81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
81: !Wait for completion of 82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
82: !Background proc 83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	eeds,
83: WAIT R[3]=1 84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !*********************************** 90: !CONTAINER2 PICK 91: !************************************	eeds,
84: 85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	
85: IF R[1]=1,JMP LBL[9999] 86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	
86: !Go to container2 pick 87: JMP LBL[1600] 88: 89: !************************************	
87: JMP LBL[1600] 88: 89: !******************************* 90: !CONTAINER2 PICK 91: !***************************** 92: 93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
88: 89: !*********************** 90: !CONTAINER2 PICK 91: !***************************** 92: 93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	r2. ———
89: !*************************** 90: !CONTAINER2 PICK 91: !************************ 92: 93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
90: !CONTAINER2 PICK 91: !*********************************** 92: 93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
91: !***************************** 92: 93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
92: 93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
93: ! Move to snapping position 94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
94: LBL[1100] 95: UFRAME_NUM=1 96: UTOOL_NUM=1	
95: UFRAME_NUM=1 96: UTOOL_NUM=1	
96: UTOOL_NUM=1	
97: J P[1101] 100% FINE — Move to a position to snap an i	nage.
98: WAIT R[3]=1	
99:	
100: LBL[1200]	
101: CALL BINPICK_ACQUIRE3DMAP('SENSOR2') — Acquire a new 3D map.	
102:	
103: LBL[1300]	
104: CALL BINPICK_SEARCH(2,1,104) Execute a SEARCH vision pro	cess.
105: IF R[104]=0,JMP LBL[1400]	
106: !SEARCH FAIL	
107: R[1]=1	
107: K[1]=1 108: JMP LBL[9999]	
108. JMF LBL[9999] 109:	
110: LBL[1400] 111: CALL BINPICK POP(2 105 106) Pop a part data from the parts l.	st.
111. Cheb bit i leit_i of (2,103,100)	ot.
112: IF R[105]=0,JMP LBL[1500]	
113: !POP FAIL 114: IMP I RI [1100] If any part data is not popped,	
to a position to spen an image	move
113.	move
116: LBL[1500]	move
117: CALL BINPICK_GETPICKPOS(2,1,107,120,121,122)	move
118: IF R[107]=0,JMP LBL[1600]	move
119: !GETPICKPOS FAIL If the BINPICK_GETPICKPOS	move
120 CALL DINDICK CETCHAT(1.22)	
120: CALL BINPICK_SETSTAT(1,22) 121: JMP LBL[1400] — pop a new part data.	
122:	S fails,
122:	S fails,
122: 123: !PICK and Start Background proc Start the background process	S fails,
122: 123: !PICK and Start Background proc 124: LBL[1600] Start the background process container1.	S fails,
122: 123: !PICK and Start Background proc 124: LBL[1600] 125: R[3]=0 Start the background process container1.	S fails,
122: 123: !PICK and Start Background proc 124: LBL[1600] Start the background process container1.	S fails,



BIN PICKING SUB1.TP

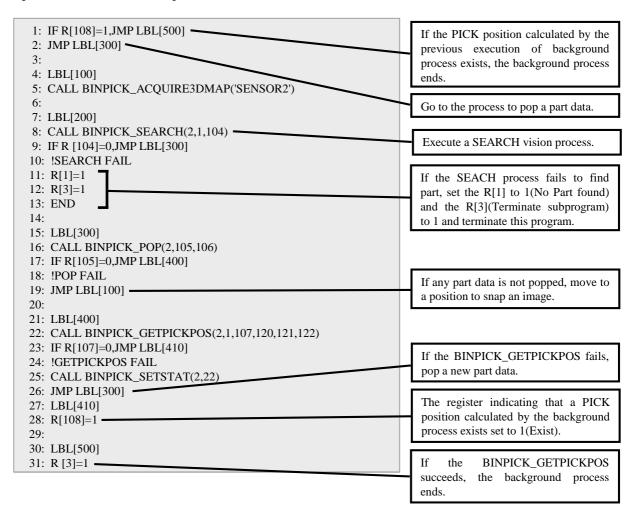
For example, for a part in Container 1, POP, PICK position acquisition, and if required, 3D map acquisition or SEARCH are performed.



Advanced Setup 2. CUSTOMIZATION

BIN PICKING SUB2.TP

For example, for a part in Container 2, POP, PICK position acquisition, and if required, 3D map acquisition or SEARCH are performed.



B-83914EN-6/02 233

2

Appendix

A TROUBLESHOOTING

A

TROUBLESHOOTING

This chapter describes problems that are likely to occur in the *i*RVision Bin Picking system and their remedies.

A.1 EXECUTING KAREL PROGRAMS FOR INTERFERENCE AVOIDANCE CAUSES AN ALARM

The following alarms may occur when the KAREL Programs for Interference Avoidance are executed. Confirm the cause of the alarm and take action.

PR[X] is uninitialized

Cause

The possible causes are described below.

- The value of the position register in which the target position is set is uninitialized.
- The value of the position register in which the frame offset value is set is uninitialized.
- The value of the position register in which the tool offset value is set is uninitialized.

Remedy

Set a target position, offset value, or tool offset value in the specified position register.

Illegal PR [X] type

Cause

The possible causes are described below.

- The value of the position register in which the target position is set is in joint format.
- The value of the position register in which the offset value is set is in joint format.
- The value of the position register in which the tool offset value is set is in joint format.

Remedy

Change the format of the target position, frame offset, or tool offset position register to cartesian or matrix format.

Illegal offset type

Cause A value other than V or O is set in the second argument of IACHECK.PC,

IACALAVOID.PC, or IAAVDWALL.PC.

Remedy Set V or O in the second argument.

A. TROUBLESHOOTING Appendix

VR[X] is uninitialized

Cause The value of the vision register in which the vision offset value is set is

uninitialized.

Remedy Set a vision offset value in the specified vision register.

CVIS-389 Invalid data is specified

Cause The possible causes are described below.

• An untaught interference setup (system) is specified.

- An untaught interference setup (robot) is specified.
- An untaught interference setup (condition) is specified.
- An interference setup (condition) of an invalid mode is specified.

Remedy Check that the specified interference setup (system), interference setup (robot), or

interference setup (condition) has been taught. Check whether an interference setup

(condition) of an invalid mode is specified.

CVIS-397 Invalid name is specified

Cause The possible causes are described below.

• A nonexistent or untaught interference setup (system) is specified.

- A nonexistent or untaught interference setup (robot) is specified.
- A nonexistent or untaught interference setup (condition) is specified.

Remedy Check that the specified interference setup (system), interference setup (robot), or

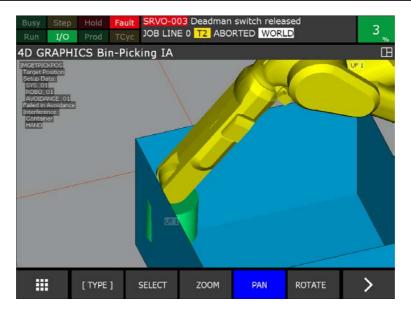
interference setup (condition) exists.

A.2 IDENTIFYING AN INTERFERING OBJECT

If it is determined that interference occurs through the interference avoidance function or parts list manager, you can check the interfering object as follows.

- On the teach pendant, press the [MENU] key \rightarrow [iRVision] \rightarrow [Bin Picking Cfg] and press the [Enter] key. The [Bin Picking Cfg] screen appears.
- 2 Move the cursor to [Interference Avoidance Configuration] and press F2 [DETAIL]. The interference avoidance configuration detail screen appears.
- 3 Move the cursor to [Update IA 4D Graphics At Run Time:] and press F4 [ON].
- 4 Re-execute the macro program (BINPICK_GETPICKPOS, etc.) or KAREL program (IMGETPICKPOS, IACALAVOID, etc.) for which it is determined that interference has occurred.
- 5 Press the [MENU] key -> [4D GRAPHICS] -> [4D Display] and press the [Enter] key. The [4D GRAPHICS Display] screen appears.
- Move the cursor to F1 [TYPE] -> [4D Bin Picking IA] and press the [Enter] key.

 The [4D GRAPHICS Bin-Picking IA] screen appears. The interfering object appears as shown in the figure below. Check the interfering object.



⚠ CAUTION

If [Update IA 4D Graphics At Run Time:] is still set to [ON] and the system is operated, the cycle time will be affected. After checking the interfering object, make sure to set [Update IA 4D Graphics At Run Time:] to [OFF].

A.3 THE ROBOT DOES NOT PROCEED TO PICK UP A PART **EVEN THOUGH THE PART IS DETECTED**

If the robot does not proceed to pick up a part even though the part is detected, only Cause

blacklist part data may remain in the parts list.

Check this using the Part Data Monitor of the Parts List Manager. If the parts list Remedy contains only blacklist part data, execute IPCLR.PC using a TP program to clear the parts list of all data including the blacklist part data. Then, execute the TP

program that performs bin picking.

A.4 THE ROBOT PROCEEDS TO PICK UP A PART WHERE NO PART IS PRESENT

If the robot proceeds to pick up a part where no part is present, the possible causes are as follows:

A part was mistakenly detected in the SEARCH or FINE vision process. Cause1

Using the monitor, check whether there is any part mistakenly detected during the Remedy1

> execution of the SEARCH or FINE vision process near the position where the robot attempted to pick up a part. If a part was mistakenly detected, adjust the vision

process parameters to prevent such mistaken detection.

Cause2 The calibration data is not correct.

A. TROUBLESHOOTING Appendix

Remedy2

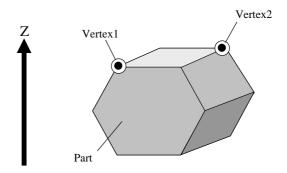
If the robot proceeds to pick up a part where no part is present even though a part has been detected properly in the SEARCH or FINE vision process, the calibration data used in the SEARCH or FINE vision process may be incorrect. Touch up the found position of the vision process using the robot in order to check whether the found position is correct. If the position is not correct, perform calibration again.

Cause3

The robot attempts to pick a part that has already been picked.

Remedy3

This phenomenon is prone to occur when the 3D Peak Locator Tool is used. Since the 3D Peak Locator Tool is intended to detect the positions of 3D points that become the highest 3D points in a region (local peaks) from a 3D point group, it may detect multiple vertexes in a single part, as shown in the following figure.



Part with multiple vertexes detected

Pushing the vertexes detected in this way to the parts list results in multiple sets of part data existing for a single part. Consequently, when part data that has Vertex 2 as its detection result is popped up after a part is picked according to the part data that has Vertex 1 as the detection result, the robot proceeds to pick up a part where no part is present, because the part has already been picked.

To prevent this phenomenon, take the following steps:

- To prevent the robot from detecting more than one vertex for a single part, set a large value in [Search Range] for the 3D Peak Locator Tool.
- To prevent the vertexes of the same part from being pushed to the parts list, set a large value in [Range] of [Duplication Check] in [Push Part Data Setup] of the Parts List Manager.
- To delete the data of the part that was near the successfully picked part and whose status is Awaiting, select [Delete] for [Process] and set a value equivalent to the size of the part in [Range] when setting the process for the part in [PICK SUCCESS] of [Status Setup List] of the Parts List Manager.

Appendix A. TROUBLESHOOTING

A.5 THE GRID FRAME SET DOES NOT OPERATE AS EXPECTED

If the Grid Frame Set does not operate as expected, first check the information provided here.

[CVIS-020 Big circles cannot be distinguished] is issued.

Cause

While measuring the grid pattern, the grid pattern cannot be detected or something that does not represent a dot is falsely detected because the exposure time is not appropriate. As a result, the alarm appears when the four large black circles of the calibration grid could not be detected.

Remedy

The Vision Runtime shows the image when a measurement failed. Check the image and adjust the conditions for image capture. When the four large dots could not be detected because some of them went outside of the camera's field of view, take any of the following measures.

- Lengthen the camera target distance so that the grid pattern is seen smaller in the field of view.
- Use a smaller grid pattern.
- Use a lens with smaller focal length.
- Rotate the camera or the grid pattern so that the X axis of the grid pattern does not point below the camera's field of view.

[CVIS-015 Too few calibration points] is issued.

Cause

While measuring the grid pattern, this alarm appears when the number of detected dots from the calibration grid is less than 4. This alarm also appears when the camera is disabled because of a hardware failure.

Remedy

Check for a hardware failure. Check whether the calibration grid is contained in the camera's field of view when the robot is placed at the measurement start position, whether the exposure time is appropriate, and whether the camera port number is correct.

The program was terminated abnormally with an error.

Cause During the grid frame setting, when an alarm appears, the program is forced to

terminate.

Remedy Modify the settings to allow for correct measurement and then execute the program

from the beginning.

A. TROUBLESHOOTING Appendix

A.6 THERE IS AN AREA IN WHICH 3D POINTS CANNOT BE ACQUIRED

If there is an area in which 3D points are not acquired, adjust the conditions for acquiring a 3D map by referring to "References: 3.4.4 Adjusting the Conditions for Acquiring a 3D Map".

If any areas where 3D points cannot be acquired persist, refer to "References: 3.4 SETUP PROCEDURES OF 3D AREA SENSOR" and ensure that the 3D Area Sensor settings are correct.

INDEX

	Changing the number of parts list223
<number></number>	Checking Calibration Point23,49,105
3D Area Sensor Configuration19,44,100	Checking Calibration Result24,49,106
3D AREA SENSOR GUIDANCE109	Checking operation217,222
3D AREA SENSOR REFERENCE109	Checking subprograms215
3D Area Sensor Setup24,50	Clear All Part Data in a Parts List155
3D Blob Locator Tool114	Command Tool Teaching30,52
3D Box Locator Tool120	CONFIGURATION AND FEATURES12
3D COG measurement tool118	Confirming the condition of the area where 3D points
3D Cylinder Locator Tool115	are not acquired126
3D Data Preprocess Tool117	Copying
3D Detection with Combination of 2D Locator Tool and	Copying TP programs211
3D Map117	Creating a 3D Area Sensor Data
3D Detection with Only 3D Map112	Creating and teaching the GPM locator tool52
3D Gripper Finger Locator Tool116	Creating and Teaching TP Program56,219,228
3D map fixed object138	Creating new data129,132
3D Obstruction Measurement Tool119	CREATING TP PROGRAM55
3D One-Sight-Model Locator Tool115	CUSTOMIZATION201
3D Peak Locator Tool113	Cylindrical fixed object
3D plane measurement tool118	Cylindrical tool object140
<a>	<d></d>
Adjusting the Conditions for Acquiring a 3D Map 125	Deleting
Adjusting the exposure time127	
Adjusting the Focus of the Camera Unit	Details of Each Teaching Operation179 Displaying the Desired Edit Screen of Parts List
Adjusting the Focus of the Projector Unit	
Adjusting the intensity127	Manager
Adjusting the Layout of 3D Area Sensor	Duplication check
Ambient Lights11	<e></e>
Automatic Recalibration	Editing
Automatic Recambiation108	Editing 3D Area Sensor Data
	Editing 5D Area Sensor Data
Basic Flow of Set Reference Wizard Operations179	Editing TP Program
BASIC OPERATION FOR INTERFERENCE SETUP129	Editing Vision Process
BASIC OPERATIONS OF PARTS LIST MANAGER150	Execute a FINE Vision Process for a Popped Part Data172
BASIC RULES OF PARTS LIST MANAGER154	EXECUTING KAREL PROGRAMS FOR
Batch Input of Register Comments	INTERFERENCE AVOIDANCE CAUSES AN
BIN PICKING 6	
BIN PICKING CONFIG	ALARM
BIN PICKING SYSTEM WITH 3D AREA SENSOR12,17,207	<f></f>
, ,	FIXED FRAME OFFSET SYSTEM WITH 3D AREA
<c></c>	SENSOR14,42,217
Calculate a FINE Position169	Flow Chart of TP Program36,55
Calculate a PICK Position160	FOV of Cameras111
Calibration22,47,104	FRAME SETTING WITH A POINTER TOOL61
Calibration Setup20,45,100	FRAME SETTING WITH THE GRID FRAME
Call BINPICK_CLEAR in a TP program155	SETTING FUNCTION88
Call BINPICK_FINE in a TP program173	FRAME SETUP REFERENCE61
Call BINPICK_GETFINEPOS in a TP program172	
Call BINPICK_GETPICKPOS in a TP program164	<g></g>
Call BINPICK_POP in a TP program159	GENERAL DESCRIPTION OF 3D AREA SENSOR
Call BINPICK_SEARCH in a TP program158	FRATURES112
Call BINPICK_SETSTAT in a TP program169	
Camera Calibration111	<h></h>
CAMERA CALIBRATION REFERENCE97	Hexahedron shaped fixed object137

HOW TO CUSTOMIZE BIN PICKING SYSTEM	< <i>R</i> >
WITH MULTIPLE CONTAINERS223	Reference Data Setup screen182
HOW TO CUSTOMIZE TO EXECUTE THE	Reference position setup screen183
SEARCH PROCESS IN THE BACKGROUND	Register Setting Table37,55,209,219,226
PROCESS207	RELATED MANUALS5
HOW TO CUSTOMIZE TO REDUCE PROCESSING	Renaming
TIME FOR SEARCH204	ROBOT COMPENSATION OPERATION CHECK41,57
HOW TO CUSTOMIZE WHEN THE CONTAINER	ROBOT-GENERATED GRID CALIBRATION97
POSITION MOVES201	Run Measurement95
	<\$>
IDENTIFYING AN INTERFERING OBJECT238	SAFETY PRECAUTIONSs-1
INSTALLATION AND CONNECTION OF 3D AREA	SEARCH VISION PROCESS SETUP
SENSOR	Selecting 3D Area Sensor Data
INTERFERENCE AVOIDANCE9	Selecting and Mounting the Target99
INTERFERENCE AVOIDANCE CONFIGURATION198	Set a Status for Popped Part Data
INTERFERENCE AVOIDANCE REFERENCE129	SET REFERENCE WIZARD178
INTERFERENCE SETUP (CONDITION)142	Set the parameters for calculating a robot position to
INTERFERENCE SETUP (ROBOT)	approach a part
INTERFERENCE SETUP (SYSTEM)134	Set up the parameters for calculating a FINE position.169
11/12/12 21/21/02 021/01 (0.10/12/12/1/)	Set up the parameters for calculating a PICK position. 160
<k></k>	Set up the parameters for deleting older part data when
KAREL PROGRAM184	part data are pushed157
KAREL PROGRAM OF INTERFERENCE	Set up the parameters for executing a FINE vision
AVOIDANCE147	process
KAREL Programs for Customizing the Parts List186	Set up the process when setting a status for a part data 166
KAREL Programs of Parts List Manager184	Set up the reference FINE position
KEY CONCEPT6	Set up the Reference PICK position
	Setting Interference Setup (Condition) Data28
<l></l>	Setting Interference Setup (Robot) Data27
Login to Interference Avoidance Setup11	Setting Interference Setup (System) Data25
Login to Parts List Manager9	Setting method types and procedures
	Setting of Data Type142
<m></m>	Setting of Fixed Object Data
MACRO PROGRAMS128	Setting of Interference Avoidance
Mounting the Calibration Grid89	Setting of Interference Check
Moving data up and down134	Setting of User Frame Number and Container
Moving the Container Object in the Interference Setup	Setting of Wall Avoidance143
Data According to the Amount of Container Travel 203	Setting PICK Position List32
	Setting SEARCH VP List32
<0>	Setting the Parameters91
Operating Objects	Setting the Tool Object
Operation for Interference Setup Data129	Setting the Type of the Parts List Manager31
OVERVIEW OF THE MANUAL3	Setting Type
JD.	SETTING UP 3D AREA SENSOR DATA 18,43,224
<p> 174</p>	Setting up the SEARCH Vision Process
PART DATA MONITOR	Settings PICK Position With Set Reference Wizard33
PARTS LIST MANAGER	SETUP OF INTERFERENCE AVOIDANCE DATA25,22
PARTS LIST MANAGER CONFIGURATION199	SETUP OF PARTS LIST MANAGER31,225
PARTS LIST MANAGER REFERENCE	Setup Procedures
PARTS LIST MANAGER SETUP AND PART DATA	SETUP PROCEDURES OF 3D AREA SENSOR 121
OPERATIONS	Shifting the Search Window According to the Amount
Pop a Part Data from a Parts List	of Container Travel203
PREFACE	Spherical fixed object136
Preparing a Container	Spherical tool object140
Process Flow	Standard Layout
Projection FOV and Standoff of Projector Unit111	SUPPORTED FUNCTIONS6
Push Some Part Data to a Parts List156	

i-2 B-83914EN-6/02

<T> TCP set up......61 Teach the Start Position94 Teaching snap tool52 Teaching the 3D data preprocess tool30,52 Teaching the 3D peak locator tool30 Teaching the 3D plane measurement tool53 Teaching the offset data calculation tool......54 TEACHING TP PROGRAM36 THE GRID FRAME SET DOES NOT OPERATE AS EXPECTED.....241 THE ROBOT DOES NOT PROCEED TO PICK UP A PART EVEN THOUGH THE PART IS DETECTED239 THE ROBOT PROCEEDS TO PICK UP A PART WHERE NO PART IS PRESENT239 THERE IS AN AREA IN WHICH 3D POINTS CANNOT BE ACQUIRED.....242 Tool Frame Setting......80 TOOL FRAME SETUP25,50 Train Model......21,46,103 TROUBLESHOOTING.....237 <U> UNMEASURABLE PARTS......121 User Frame Setting......61 USER FRAME SETUP......18,43 Using an Image Register204 <*V*>

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B-83914EN-6/02

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