FANUC Robot series

R-30*i*B/R-30*i*B Mate CONTROLLER

Force Control Deburring Package

OPERATOR'S MANUAL

B-83424EN-1/02

• Original Instructions

Thank you very much for purchasing FANUC Robot.

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

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

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

SAFETY PRECAUTIONS

This chapter describes the precautions which must be observed to ensure the safe use of the robot.
Before attempting to use the robot, be sure to read this chapter thoroughly.

Before using the functions related to robot operation, read the relevant operator's manual to become familiar with those functions.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral devices installed in a work cell.
In addition, refer to the "FANUC Robot SAFETY HANDBOOK (B-80687EN)".

1 WORKING PERSON

The personnel can be classified as follows.

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

Programmer or teaching operator:
- Operates the robot
- Teaches robot inside the safety fence

Maintenance engineer:
- Operates the robot
- Teaches robot inside the safety fence
- Maintenance (adjustment, replacement)

- An operator cannot work inside the safety fence.
- A programmer, teaching operator, and maintenance engineer can work inside the safety fence. The working activities inside the safety fence include lifting, setting, teaching, adjusting, maintenance, etc.
- To work inside the fence, the person must be trained on proper robot operation.

During the operation, programming, and maintenance of your robotic system, the programmer, teaching operator, and maintenance engineer should take additional care of their safety by using the following safety precautions.

- Use adequate clothing or uniforms during system operation
- Wear safety shoes
- Use helmet

2 DEFINITION OF WARNING, CAUTION AND NOTE

To ensure the safety of working persons 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 attempting to use the robots.

> ⚠**WARNING**
> Used if a danger resulting in the death or serious injury of the user is expected to occur if he or she fails to observe the approved procedure.

> ⚠**CAUTION**
> Used if a danger resulting in the minor or moderate injury of the user or equipment damage is expected to occur if he or she fails to observe the approved procedure.

> **NOTE**
> Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

- Read this manual carefully, and store it in a safe place.

3 WORKING PERSON SAFETY

Working person safety is the primary safety consideration. Because it is very dangerous to enter the operating space of the robot during automatic operation, adequate safety precautions must be observed.
The following lists the general safety precautions. Careful consideration must be made to ensure working person safety.

(1) Have the robot system working persons attend the training courses held by FANUC.

> FANUC provides various training courses. Contact our sales office for details.

(2) Even when the robot is stationary, it is possible that the robot is still in a ready to move state, and is waiting for a signal. In this state, the robot is regarded as still in motion. To ensure working person safety, provide the system with an alarm to indicate visually or aurally that the robot is in motion.
(3) Install a safety fence with a gate so that no working person can enter the work area without passing through the gate. Install an interlocking device, a safety plug, and so forth in the safety gate so that the robot is stopped as the safety gate is opened.

> The controller is designed to receive this interlocking signal of the door switch. When the gate is opened and this signal received, the controller stops the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). For connection, see Fig.3 (a) and Fig.3 (b).

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).
(5) Try to install the peripheral devices outside the work area.
(6) Draw an outline on the floor, clearly indicating the range of the robot motion, including the tools such as a hand.
(7) Install a mat switch or photoelectric switch on the floor with an interlock to a visual or aural alarm that stops the robot when a working person enters the work area.
(8) If necessary, install a safety lock so that no one except the working person in charge can turn on the power of the robot.

The circuit breaker installed in the controller is designed to disable anyone from turning it on when it is locked with a padlock.

(9) When adjusting each peripheral device independently, be sure to turn off the power of the robot.
(10) Operators should be ungloved while manipulating the operator's panel or teach pendant. Operation with gloved fingers could cause an operation error.
(11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident.
(12) The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
(13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
(14) Before the robot is started, it should be checked that no one is in the area of the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.
(15) When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
  - Avoid using the robot in a flammable environment.
  - Avoid using the robot in an explosive environment.
  - Avoid using the robot in an environment full of radiation.
  - Avoid using the robot under water or at high humidity.
  - Avoid using the robot to carry a person or animal.
  - Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)
(16) When connecting the peripheral devices related to stop(safety fence etc.) and each signal (external emergency , fence etc.) of robot. be sure to confirm the stop movement and do not take the wrong connection.
(17) When preparing trestle, please consider security for installation and maintenance work in high place according to Fig.3 (c). Please consider footstep and safety belt mounting position.

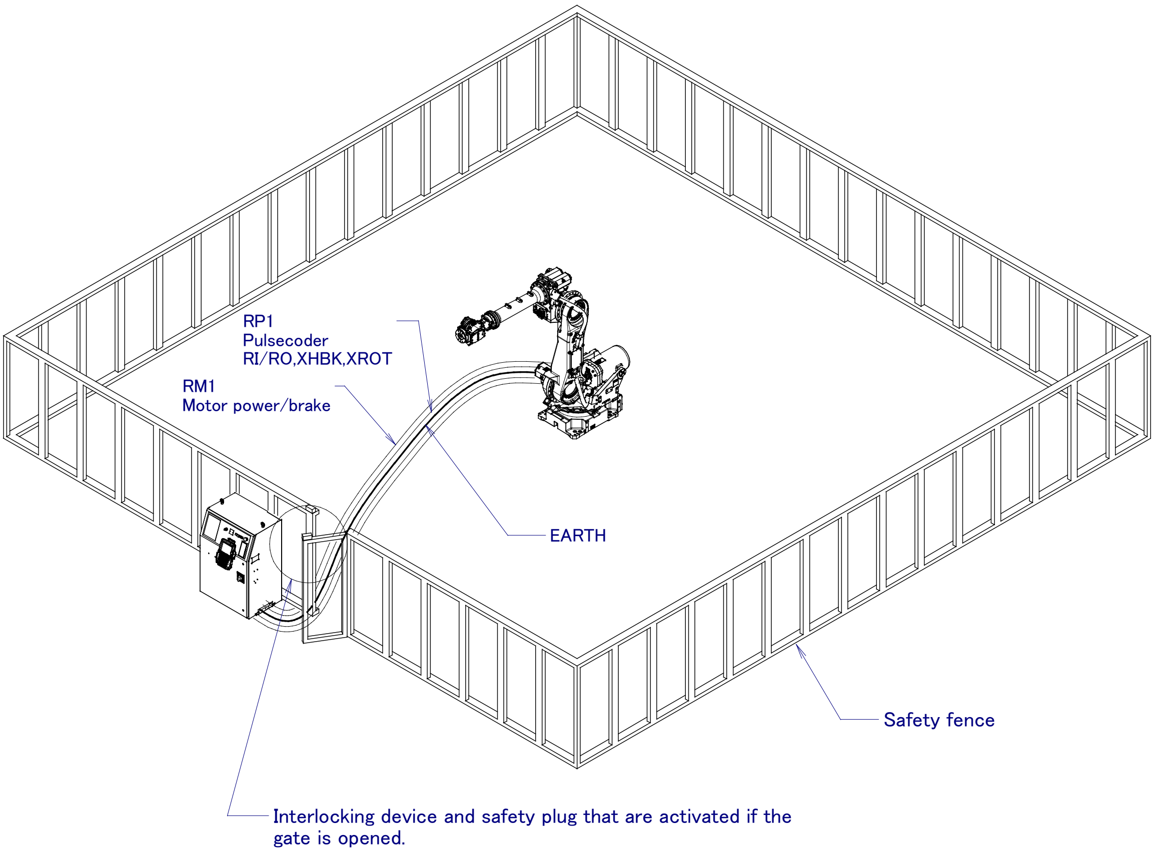
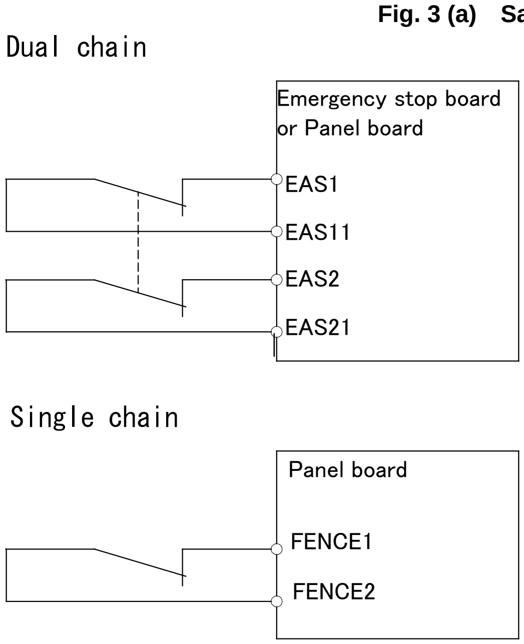


Fig. 3 (a) Safety fence and safety gate



(Note)

In case of R-30*i*B, R-30*i*B Mate
Terminals EAS1,EAS11,EAS2,EAS21 are provided on the emergency stop board.

Refer to the ELECTRICAL CONNCETIONS Chapter of CONNECTION of
R-30*i*B controller maintenance manual (B-83195EN) or
R-30*i*B Mate controller maintenance manual (B-83525EN)
or R-30*i*B Mate controller (Open Air) maintenance manual (B-83525EN) for details.

Fig. 3 (b) Limit switch circuit diagram of the safety fence

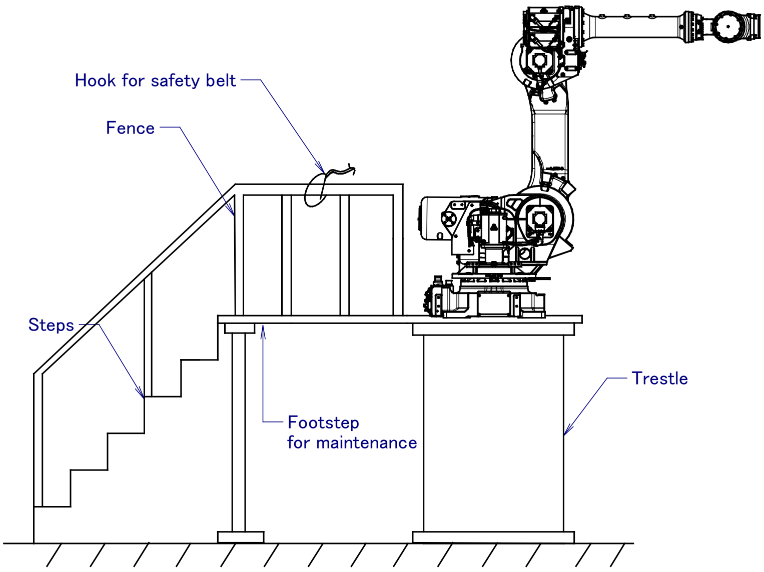


Fig.3 (c) Footstep for maintenance

3.1 OPERATOR SAFETY

The operator is a person who operates the robot system. In this sense, a worker who operates the teach pendant is also an operator. However, this section does not apply to teach pendant operators.

(1) If you do not have to operate the robot, turn off the power of the robot controller or press the EMERGENCY STOP button, and then proceed with necessary work.
(2) Operate the robot system at a location outside of the safety fence
(3) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the work area unexpectedly and to prevent the worker from entering a dangerous area.
(4) Install one or more necessary quantity of EMERGENCY STOP button(s) within the operator's reach in appropriate location(s) based on the system layout.

The robot controller is designed to be connected to an external EMERGENCY STOP button. With this connection, the controller stops the robot operation (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type), when the external EMERGENCY STOP button is pressed. See the diagram below for connection.

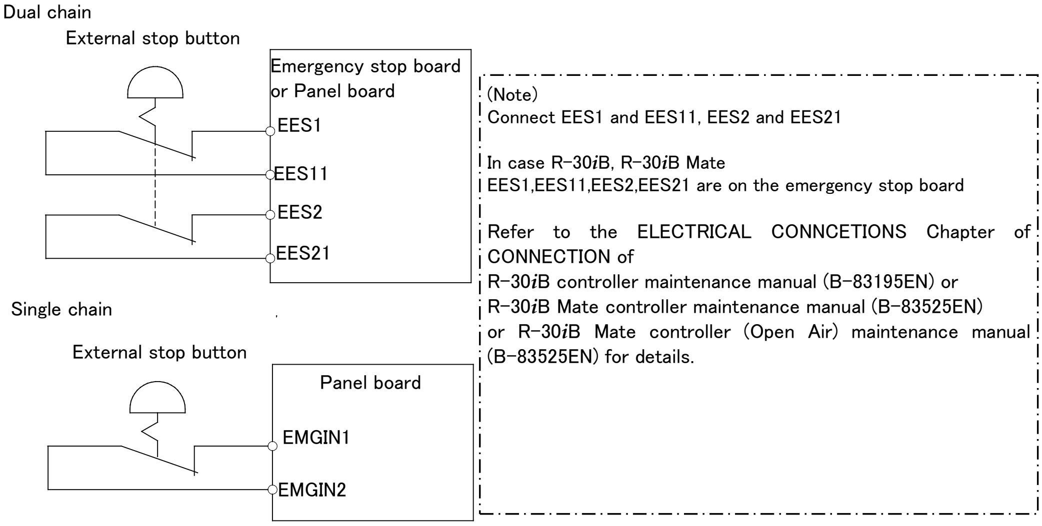


Fig.3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator must enter the work area of the robot. The operator must ensure the safety of the teach pendant operator especially.

(1) Unless it is specifically necessary to enter the robot work area, carry out all tasks outside the area.
(2) Before teaching the robot, check that the robot and its peripheral devices are all in the normal operating condition.
(3) If it is inevitable to enter the robot work area to teach the robot, check the locations, settings, and other conditions of the safety devices (such as the EMERGENCY STOP button, the DEADMAN switch on the teach pendant) before entering the area.
(4) The programmer must be extremely careful not to let anyone else enter the robot work area.
(5) Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer should take the following precautions:
   - Before entering the area of the safety fence, ensure that there is no risk of dangerous situations in the area.
   - Be prepared to press the emergency stop button whenever necessary.
   - Robot motions should be made at low speeds.
   - Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would be dangerous to the working person.

> Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation mode set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence.

> Our teach pendant is provided with a DEADMAN switch as well as an emergency stop button. These button and switch function as follows:
> (1) Emergency stop button: Causes the stop of the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type) when pressed.
> (2) DEADMAN switch: Functions differently depending on the teach pendant enable/disable switch setting status.
> (a) Disable: The DEADMAN switch is disabled.
> (b) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
> Note) The DEADMAN switch is provided to stop the robot when the operator releases the teach pendant or presses the pendant strongly in case of emergency. The R-30*i*B/R-30*i*B Mate employs a 3-position DEADMAN switch, which allows the robot to operate when the 3-position DEADMAN switch is pressed to its intermediate point. When the operator releases the DEADMAN switch or presses the switch strongly, the robot stops immediately.

> The programmer’s intention of starting teaching is determined by the controller through the dual operation of setting the teach pendant enable/disable switch to the enable position and pressing the DEADMAN switch. The programmer should make sure that the robot could operate in such conditions and be responsible in carrying out tasks safely.

> Based on the risk assessment by FANUC, number of operation of DEADMAN SW should not exceed about 10000 times per year.

The teach pendant, operator panel, and peripheral device interface send each robot start signal. However the validity of each signal changes as follows depending on the mode switch and the DEADMAN switch of the operator panel, the teach pendant enable switch and the remote condition on the software.

Mode	Teach pendant enable switch	Software remote condition	Teach pendant	Operator panel	Peripheral device
AUTO mode	On	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed
	Off	Local	Not allowed	Allowed to start	Not allowed
		Remote	Not allowed	Not allowed	Allowed to start
T1, T2 mode	On	Local	Allowed to start	Not allowed	Not allowed
		Remote	Allowed to start	Not allowed	Not allowed
	Off	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed

T1,T2 mode: DEADMAN switch is effective.

(6) To start the system using the operator's panel, make certain that nobody is the robot work area and that there are no abnormal conditions in the robot work area.
(7) When a program is completed, be sure to carry out a test operation according to the procedure below.
  (a) Run the program for at least one operation cycle in the single step mode at low speed.
  (b) Run the program for at least one operation cycle in the continuous operation mode at low speed.
  (c) Run the program for one operation cycle in the continuous operation mode at the intermediate speed and check that no abnormalities occur due to a delay in timing.
  (d) Run the program for one operation cycle in the continuous operation mode at the normal operating speed and check that the system operates automatically without trouble.
  (e) After checking the completeness of the program through the test operation above, execute it in the automatic operation mode.
(8) While operating the system in the automatic operation mode, the teach pendant operator should leave the robot work area.

3.3 SAFETY OF THE MAINTENANCE ENGINEER

For the safety of maintenance engineer personnel, pay utmost attention to the following.

(1) During operation, never enter the robot work area.
(2) A hazardous situation may arise when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system should be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed.
(3) If it becomes necessary to enter the robot operation range while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the range. The maintenance personnel must indicate that maintenance work is in progress and be careful not to allow other people to operate the robot carelessly.
(4) When entering the area enclosed by the safety fence, the maintenance worker must check the entire system in order to make sure no dangerous situations exist. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and entire system status must be carefully monitored.
(5) Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.

(6) Before the start of teaching, check that the robot and its peripheral devices are all in the normal operating condition.
(7) Do not operate the robot in the automatic mode while anybody is in the robot work area.
(8) When you maintain the robot alongside a wall or instrument, or when multiple workers are working nearby, make certain that their escape path is not obstructed.
(9) When a tool is mounted on the robot, or when any moving device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.
(10) If necessary, have a worker who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the worker should be ready to press the EMERGENCY STOP button at any time.
(11) When replacing a part, please contact FANUC service center. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the worker.
(12) When replacing or reinstalling components, take care to prevent foreign material from entering the system.
(13) When handling each unit or printed circuit board in the controller during inspection, turn off the circuit breaker to protect against electric shock.
If there are two cabinets, turn off the both circuit breaker.
(14) A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
(15) When restarting the robot system after completing maintenance work, make sure in advance that there is no person in the work area and that the robot and the peripheral devices are not abnormal.
(16) When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.
(17) Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.
(18) The following parts are heated. If a maintenance worker needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.
- Servo motor
- Inside the controller
- Reducer
- Gearbox
- Wrist unit
(19) Maintenance should be done under suitable light. Care must be taken that the light would not cause any danger.
(20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.
(21) The robot should not be stepped on or climbed up during maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
(22) When performing maintenance work in high place, secure a footstep and wear safety belt.
(23) After the maintenance is completed, spilled oil or water and metal chips should be removed from the floor around the robot and within the safety fence.
(24) When a part is replaced, all bolts and other related components should put back into their original places. A careful check must be given to ensure that no components are missing or left not mounted.
(25) In case robot motion is required during maintenance, the following precautions should be taken :
- Foresee an escape route. And during the maintenance motion itself, monitor continuously the whole system so that your escape route will not become blocked by the robot, or by peripheral equipment.
- Always pay attention to potentially dangerous situations, and be prepared to press the emergency stop button whenever necessary.
(26) The robot should be periodically inspected. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can adversely affect the performance or service life of the robot and may cause an accident

(27) After a part is replaced, a test operation should be given for the robot according to a predetermined method. (See TESTING section of “R-30iB/R-30iB Mate Controller operator’s manual (Basic Operation)”.) During the test operation, the maintenance staff should work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL DEVICES

4.1 PRECAUTIONS IN PROGRAMMING

(1) Use a limit switch or other sensor to detect a dangerous condition and, if necessary, design the program to stop the robot when the sensor signal is received.
(2) Design the program to stop the robot when an abnormal condition occurs in any other robots or peripheral devices, even though the robot itself is normal.
(3) For a system in which the robot and its peripheral devices are in synchronous motion, particular care must be taken in programming so that they do not interfere with each other.
(4) Provide a suitable interface between the robot and its peripheral devices so that the robot can detect the states of all devices in the system and can be stopped according to the states.

4.2 PRECAUTIONS FOR MECHANISM

(1) Keep the component cells of the robot system clean, and operate the robot in an environment free of grease, water, and dust.
(2) Don’t use unconfirmed liquid for cutting fluid and cleaning fluid.
(3) Employ a limit switch or mechanical stopper to limit the robot motion so that the robot or cable does not strike against its peripheral devices or tools.
(4) Observe the following precautions about the mechanical unit cables. Failure to follow precautions may cause mechanical troubles.
   - Use mechanical unit cable that have required user interface.
   - Don’t add user cable or hose to inside of mechanical unit.
   - Please do not obstruct the movement of the mechanical unit cable when cables are added to outside of mechanical unit.
   - In the case of the model that a cable is exposed, Please do not perform remodeling (Adding a protective cover and fix an outside cable more) obstructing the behavior of the outcrop of the cable.
   - When installing user peripheral equipment on the robot mechanical unit, please pay attention that equipment does not interfere with the robot itself.
(5) The frequent power-off stop for the robot during operation causes the trouble of the robot. Please avoid the system construction that power-off stop would be operated routinely. (Refer to bad case example.) Please execute power-off stop after reducing the speed of the robot and stopping it by hold stop or cycle stop when it is not urgent. (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type.)
   (Bad case example)
   - Whenever poor product is generated, a line stops by emergency stop and power-off of the robot is executed.
   - When alteration was necessary, safety switch is operated by opening safety fence and power-off stop is executed for the robot during operation.
   - An operator pushes the emergency stop button frequently, and a line stops.
   - An area sensor or a mat switch connected to safety signal operate routinely and power-off stop is executed for the robot.

(6) Power-off stop of Robot is executed when collision detection alarm (SRVO-050) etc. occurs. Please try to avoid unnecessary power-off stops. It may cause the trouble of the robot, too. So remove the causes of the alarm.

5 SAFETY OF THE ROBOT MECHANISM

5.1 PRECAUTIONS IN OPERATION

(1) When operating the robot in the jog mode, set it at an appropriate speed so that the operator can manage the robot in any eventuality.
(2) Before pressing the jog key, be sure you know in advance what motion the robot will perform in the jog mode.

5.2 PRECAUTIONS IN PROGRAMMING

(1) When the work areas of robots overlap, make certain that the motions of the robots do not interfere with each other.
(2) Be sure to specify the predetermined work origin in a motion program for the robot and program the motion so that it starts from the origin and terminates at the origin.
Make it possible for the operator to easily distinguish at a glance that the robot motion has terminated.

5.3 PRECAUTIONS FOR MECHANISMS

(1) Keep the work areas of the robot clean, and operate the robot in an environment free of grease, water, and dust.

5.4 PROCEDURE TO MOVE ARM WITHOUT DRIVE POWER IN EMERGENCY OR ABNORMAL SITUATIONS

For emergency or abnormal situations (e.g. persons trapped in or pinched by the robot), brake release unit can be used to move the robot axes without drive power.
Please refer to controller maintenance manual and mechanical unit operator’s manual for using method of brake release unit and method of supporting robot.

6 SAFETY OF THE END EFFECTOR

6.1 PRECAUTIONS IN PROGRAMMING

(1) To control the pneumatic, hydraulic and electric actuators, carefully consider the necessary time delay after issuing each control command up to actual motion and ensure safe control.
(2) Provide the end effector with a limit switch, and control the robot system by monitoring the state of the end effector.

7 STOP TYPE OF ROBOT

The following three robot stop types exist:

Power-Off Stop (Category 0 following IEC 60204-1)

Servo power is turned off and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.
The following processing is performed at Power-Off stop.

- An alarm is generated and servo power is turned off.
- The robot operation is stopped immediately. Execution of the program is paused.

Frequent Power-Off stop of the robot during operation can cause mechanical problems of the robot.
Avoid system designs that require routine or frequent Power-Off stop conditions.

Controlled stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
The following processing is performed at Controlled stop.

- The alarm "SRVO-199 Controlled stop" occurs along with a decelerated stop. Execution of the program is paused.
- An alarm is generated and servo power is turned off.

Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.
The following processing is performed at Hold.

- The robot operation is decelerated until it stops. Execution of the program is paused.

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time of Power-Off stop. A risk assessment for the whole robot system, which takes into consideration the increased stopping distance and stopping time, is necessary when Controlled stop is used.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Power-Off stop or Controlled stop. The configuration of stop type for each situation is called *stop pattern*. The stop pattern is different according to the controller type or option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Servo disconnect
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
B	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
C	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	C-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop

P-Stop: Power-Off stop
C-Stop: Controlled stop

-: Disable

The following table indicates the Stop pattern according to the controller type or option configuration.

Option	R-30*i*B/ R-30*i*B Mate
Standard	A (*)
Controlled stop by E-Stop (A05B-2600-J570)	C (*)

(*) R-30*i*B / R-30*i*B Mate does not have servo disconnect. R-30*i*B Mate does not have SVOFF input.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer to "Software version" in operator's manual of controller for the detail of software version screen.

"Controlled stop by E-Stop" option

When "Controlled stop by E-Stop" (A05B-2600-J570) option is specified, the stop type of the following alarms becomes Controlled stop but only in AUTO mode. In T1 or T2 mode, the stop type is Power-Off stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Controlled stop is different from Power-Off stop as follows:

- In Controlled stop, the robot is stopped on the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Controlled stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and stopping time of Controlled stop is longer than the stopping distance and stopping time of Power-Off stop, depending on the robot model and axis. Please refer to the operator's manual of a particular robot model for the data of stopping distance and stopping time.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time of Power-Off stop. A risk assessment for the whole robot system, which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

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APPENDIX

1 PREFACE

This chapter describes the overview of this manual. Read the following before using the Force Control Deburring package.

1.1 OVERVIEW OF THE MANUAL

This manual describes how to operate the Force Control Deburring package of R-30*i*B/R-30*i*B Mate Controller.

> ⚠ **CAUTION**
> This manual is written on the basis of PC software ROBOGUIDE (V8 Rev.J (7N08/10) edition) which simulates robot operations and R-30*i*B/R-30*i*B Mate Controller software (7DC3/06, 7DC2/20 or 7DC1/26 edition). Depending on the software edition, there may be functions and setting items that are not described in this manual or some of the notation may differ.

This manual describes some of the ROBOGUIDE, *i*RVision and force control functions contained in the Force Control Deburring package. If you want to know the exact meaning of arguments for individual setting items and instructions, refer to the manuals listed in Section 1.2, "RELATED MANUALS".

Overview of each chapter in this manual

Chapter 1	How to use this manual
Chapter 2	Overview of the Force Control Deburring package, the structure of the system, and so on
Chapter 3	Offline teaching procedure with ROBOGUIDE
Chapter 4	Online teaching procedure with the robot
Chapter 5	Online running procedure on the robot
Appendix A	Troubleshooting
Appendix B	How to simulate deburring operations with ROBOGUIDE
Appendix C	Sample TP programs automatically generated by ROBOGUIDE and the robot

1.2 RELATED MANUALS

This section introduces other related manuals and online help for reference, which are helpful when the functions of the Force Control Deburring package are used.

ROBOGUIDE OPERATOR’S MANUAL B-83234EN

This manual describes the following contents about ROBOGUIDE.

- Configuration of ROBOGUIDE
- Flow of operating ROBOGUIDE
- Limitations of ROBOGUIDE
- Hardware requirements
- Installation and uninstallation
- Licenses of ROBOGUIDE
- Starting and exiting ROBOGUIDE
- How to use the tutorial
- How to use the online help
- Creating a workcell
- Features of ROBOGUIDE

ROBOGUIDE Online Help

This online help describes the features of ROBOGUIDE, how to use each function, the tutorial, etc.
This can be accessed from the ROBOGUIDE menu "Help" → "Contents".

R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR’S MANUAL (Basic Operation) B-83284EN

This is the main manual of R-30*i*B/R-30*i*B Mate Controller. This manual describes the following items for manipulating workpieces with the robot:

- 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 on an applicable design, robot installation, robot teaching, etc.

R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR’S MANUAL (Alarm Code List) B-83284EN-1

This manual describes the error code listings, causes, and remedies of R-30*i*B/R-30*i*B Mate Controller.

R-30*i*B/R-30*i*B Mate CONTROLLER Optional Function OPERATOR’S MANUAL B-83284EN-2

This manual describes the software optional functions of R-30*i*B/R-30*i*B Mate Controller.

R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate CONTROLLER Ethernet Function OPERATOR’S MANUAL B-82974EN

This manual describes the robot networking options such as FTP, RIPE, PC Share, and so on.

R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR’S MANUAL (Reference) B-83304EN

This manual is the reference manual for *i*RVision on the R-30*i*B/R-30*i*B Mate controller. This manual describes each functions which are provided by *i*RVision. This manual describes the meanings of. the items on *i*RVision setup screen, the arguments of the instruction, and so on.

R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RVision 2D Vision Application OPERATOR’S MANUAL B-83304EN-1

This manual is desired to first refer to when you start up systems of *i*RVision 2D Compensation and 2.5D Compensation. This manual describes startup procedures of *i*RVision 2D Compensation and 2.5D Compensation system, creating programs, caution, technical know-how, response to several cases, and so on.

R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision 3D Laser Vision Sensor Application OPERATOR’S MANUAL B-83304EN-2

This manual is desired to first refer to when you start up systems of *i*RVision 3D Laser Sensor Compensation. This manual describes startup procedures of *i*RVision 3D Laser Sensor Compensation, creating programs, caution, technical know-how, response to several cases, and so on.

R-30*i*B/R-30*i*B Mate CONTROLLER Force Sensor OPERATOR'S MANUAL B-83424EN

This manual describes how to operate a force sensor controlled by the R-30*i*B controller. In this manual, only the operations and the technique of programming for the force control functions are explained assuming that the installation and setup of the robot have been completed.

R-30*i*B CONTROLLER MAINTENANCE MANUAL B-83195EN

This manual describes the maintenance and connection of R-30*i*B Controller.

R-30*i*B Mate CONTROLLER MAINTENANCE MANUAL B-83525EN

This manual describes the maintenance and connection of R-30*i*B Mate Controller.

R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit / Control Unit OPERATOR'S MANUAL B-83434EN

This manual describes the connection between sensors which is a camera or 3D Laser Sensor and R-30*i*B/R-30*i*B Mate Controller, and maintenance of sensors.

1.3 PRECAUTIONS FOR 3D LASER VISION SENSOR

This section describes precautions to be taken for the 3D Laser Vision Sensor before using it.

1.3.1 Safety of Laser Sensor

The 3D Laser Vision Sensor is a visual sensor, which detects the position and posture of an object using semiconductor lasers.

> ⚠ **CAUTION**
> Observe user's safety and fire precautions in accordance with the safety standards and the regulations, which the country and the region provide when you use this sensor. Moreover, when the safety standards and regulations are changed or newly enacted, please follow them.

The laser classification used in the sensor
Semiconductor lasers → Class IIIa Laser (cf. FDA 1040.10)
Class 3R Laser (cf. IEC Pub.60825 / JIS C6802)

1.3.2 Laser Beam

The semiconductor laser beam is a visible optical laser with a wave length of 650nm. It is necessary to pay attention to its operation though the maximum output power is at most 4.5mW x 2. Do not irradiate the output beam from the sensor directly to your eyes. Moreover, do not look straight at the scattered light for a long time.

1.3.3 Warning Label

The warning labels which inform the danger of the laser beam irradiation are affixed on this laser sensor. Moreover, the warning labels in accordance with United States FDA standard are prepared as an option. Fig. 1.3.3 (a) and Fig. 1.3.3 (b) show the warning labels used.

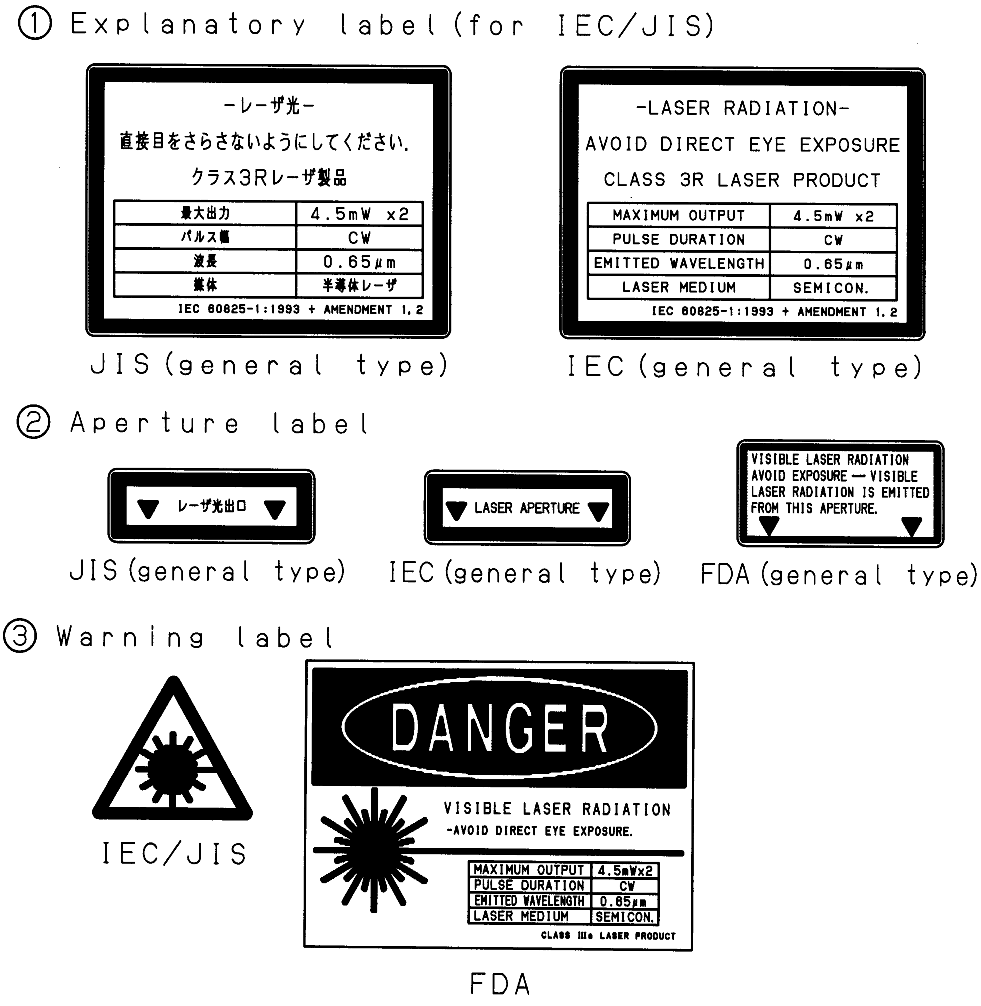


Fig. 1.3.3 (a) Warning labels (1)

④ Address label (for FDA)

3580, Shibokusa Aza-Komanba.
Oshino-mura, Minamitsuru-gun,
Yamanashi Prefecture, Japan

⑤ Access panel label

注意 ―ここを開くとクラス3Rレーザ光が
出ます.
直接目をさらさないようにしてください.

JIS

CAUTION ― CLASS 3R LASER
RADIATION WHEN OPEN.
AVOID DIRECT EYE EXPOSURE.

IEC

DANGER
VISIBLE LASER RADIATION
WHEN OPEN.
AVOID DIRECT EYE EXPOSURE.

FDA

⑥ Certification label (for FDA)

- CERTIFICATION LABEL -
• This laser product complies
with 21 CFR 1040.10 and 1040.11.

Fig. 1.3.3 (b) Warning labels (2)

2 FORCE CONTROL DEBURRING PACKAGE

This package, in conjunction with ROBOGUIDE, *i*RVision and force control functions, automatically generates robot programs for removing burrs on machined surfaces of castings and the like, and performs the deburring procedures.
Combined with ROBOGUIDE and *i*RVision, this package can automatically generate deburring programs for each actual workpiece. There is no need to teach the robot at multiple teaching points manually, so the man-hour of teaching processes can be reduced significantly.

2.1 OPERATING PROCEDURE

The operating procedure for this package is as shown below. (Fig. 2.1)

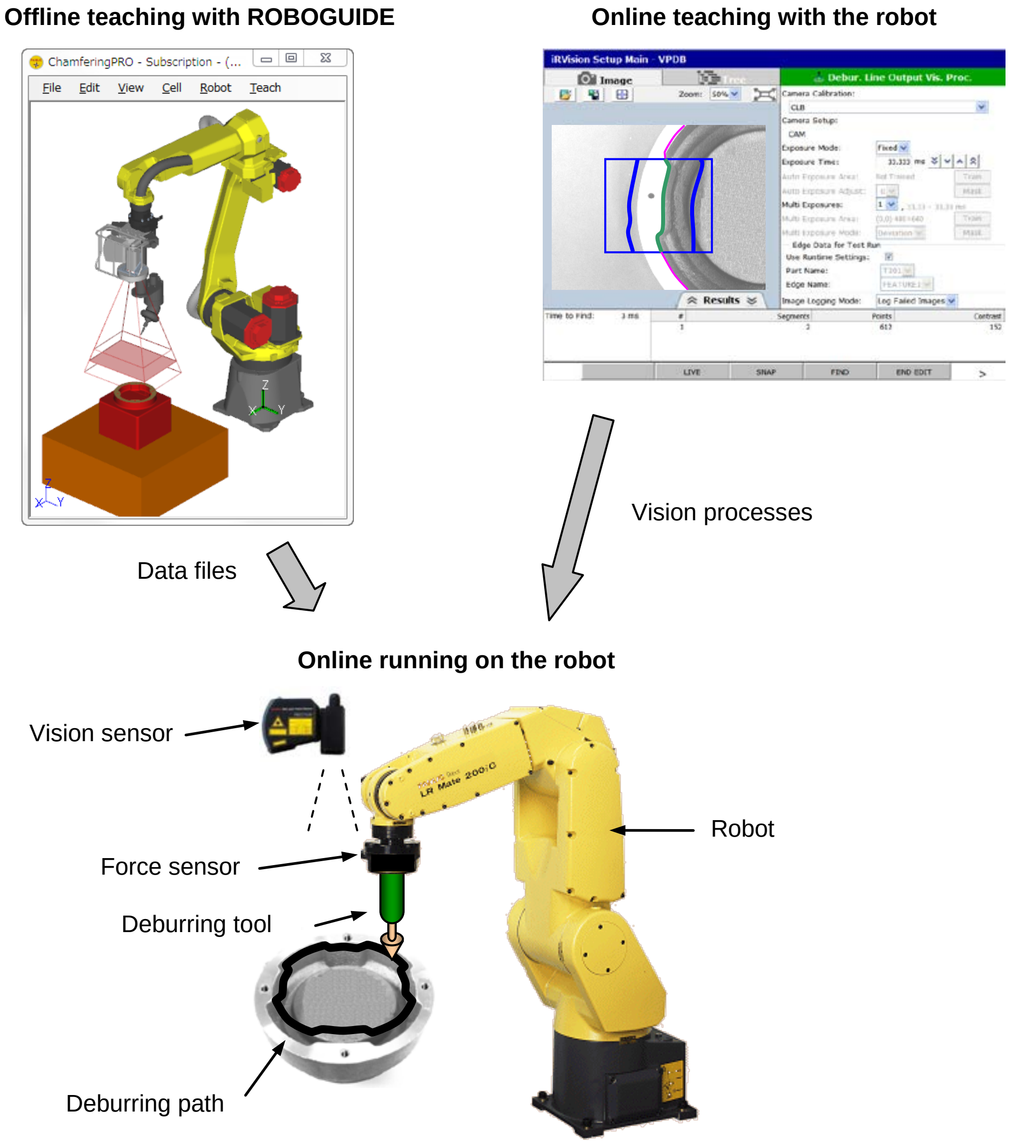


Fig. 2.1 Operating procedure for the deburring package

Offline teaching with ROBOGUIDE

A workcell is created, edges and targets (feature portions detected by *i*RVision for calculating the position of a workpiece to be deburred) are taught, and data files are generated. For details, see Chapter 3, "OFFLINE TEACHING WITH ROBOGUIDE".

Online teaching with the robot

Vision offset and Deburring Line Output vision processes are taught. For details, see Chapter 4, "ONLINE TEACHING WITH THE ROBOT".

Online running on the robot

By use of the data files generated by ROBOGUIDE, the vision processes taught with the robot, etc., the base position and edges on a workpiece are detected and deburring paths are automatically generated. Then, the edges are deburred with the Force Control Contouring function. For details, see Chapter 5, "ONLINE RUNNING ON THE ROBOT".

2.2 FUNCTIONS OF THE PACKAGE

This package performs the following ROBOGUIDE, *i*RVision and force control functions.

ROBOGUIDE

Information required for deburring is set offline and various data files to be loaded into the robot are generated. First, the deburring tool, 3D Laser Vision Sensor and the like are placed as in the case of the actual robot system. Next, a CAD model for a workpiece to be machined is imported and edges to be machined are specified. After the setup is complete, with the data file generation function, various data files necessary for deburring are generated such as a TP program for detecting the position and orientation of a workpiece, TP programs for finding edges of a workpiece, and other TP programs. Loading these data files into the robot can make the robot perform deburring.
In addition, the generated data files can be used to simulate deburring operations on ROBOGUIDE. For the deburring operation simulation on ROBOGUIDE, see Appendix B, "SIMULATING DEBURRING OPERATIONS WITH ROBOGUIDE".

*i*RVision

In this package, *i*RVision performs the following two functions: detecting target positions and finding edges.

1 To obtain the position and orientation of a workpiece, three targets on the workpiece are detected by using the 3D Laser Vision Sensor attached to the wrist of the robot. From the positions of three targets, the position and orientation of the workpiece are obtained. (Fig. 2.2(a))

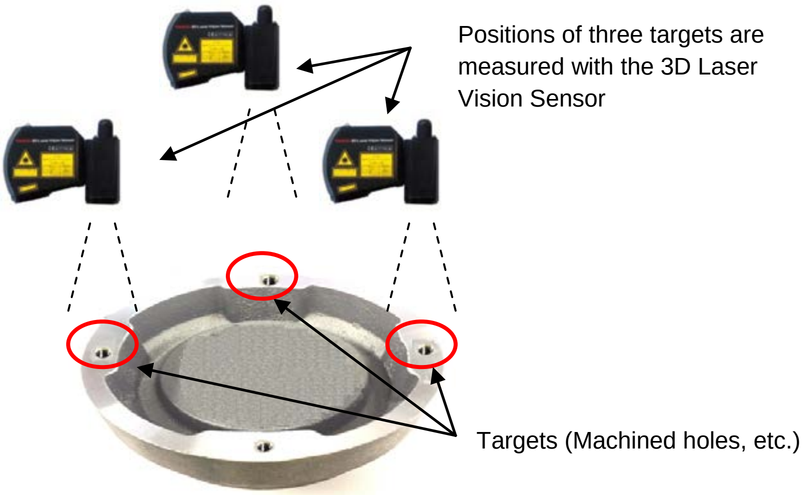


Fig. 2.2(a) Detecting target positions

2 On the basis of edge data generated by ROBOGUIDE, edges for a workpiece are found from the image. By obtaining intersections between view lines passing through found edges on the image and the plane corresponding to the surface of the workpiece, the positions of the edges in the 3D space are obtained. This is used for deburring path auto generation for the robot. (Fig. 2.2(b))

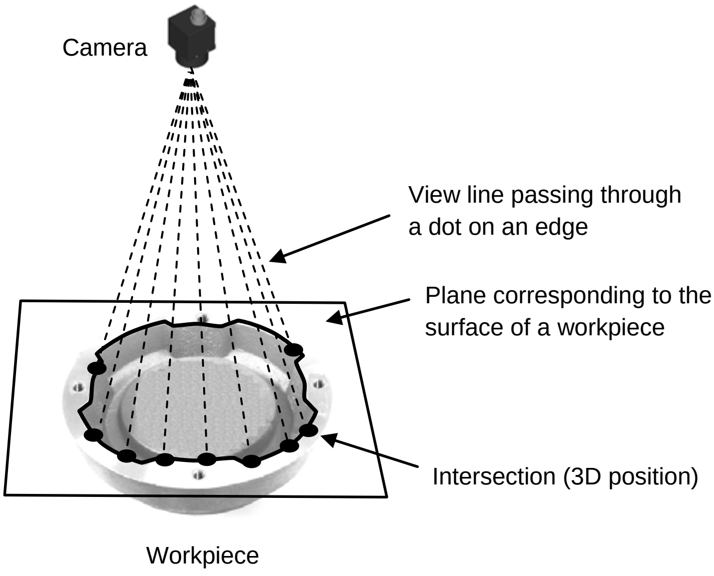


Fig. 2.2(b) Finding an edge

Force control

By using the positions of edges found by *i*RVision, a program that causes the robot to perform deburring is automatically generated. In deburring, the Force Control Contouring function is used to control the pushing force to a specific value in the direction from the tool toward the edges, thereby improving machining quality. The positions of edges found by *i*RVision contains a small error, but the impact of the error can be reduced by monitoring and controlling the force with force sensor during deburring.

2.2.1 Description of Terms

This subsection describes the terms used in this package.

Data files

A group of files generated by ROBOGUIDE for each workpiece. Loading data files generated by ROBOGUIDE into the robot can make the robot deburr a specified workpiece.

Edge data

Files in which edge shape data and the like are described, which are generated as part of data files. The *i*RVision Deburring Line Output Vision Process uses this information to find an edge.

Targets

Features on the workpiece detected by *i*RVision to determine the position and orientation of a workpiece. Normally, three targets are detected by the 3D Laser Vision Sensor or a camera. The vision processes which detect targets should be taught for each type of workpiece. The three targets need not be on the same plane. For the target setting method, see Section 3.4, "SETTING TARGETS".

2.3 STRUCTURE OF THE DEBURRING SYSTEM

The system to which the Force Control Deburring package is applied needs the following elements.

- R-30iB/R-30iB Mate Controller
- Vision sensor (3D Laser Vision Sensor or camera)
  Attached to the wrist of the robot (robot-mounted camera) or fixed (fixed camera).
- External LED light
  Installed on the tip of the vision sensor or its periphery.
- Force sensor
  Attached to the wrist of the robot (robot-mounted sensor) or fixed (fixed sensor).
  For details about the force sensor installation method, see Appendix C, "FORCE SENSOR ATTACHMENT SETTING FUNCTION" of "R-30iB/R-30iB Mate CONTROLLER Force Sensor OPERATOR’S MANUAL B-83424EN".
- Deburring Tool
  Attached to the wrist of the robot to deburr edges.

Only when calibrating the 3D Laser Vision Sensor or a camera, the Calibration Grid is required.

2.3.1 Selecting a Vision Sensor

2.3.1.1 Examples of vision sensor installation

A vision sensor (3D Laser Vision Sensor or camera) can be installed in the following three ways in this package. Basically, use item 1 below. Other configurations can only be used in special cases.

1 The 3D Laser Vision Sensor is attached to the wrist of the robot and used as a robot-mounted camera. (Fig. 2.3.1.1(a))
  This configuration is supported when the position or orientation of a workpiece is shifted as well as when there are multiple machined surfaces or the size of a machined surface is large.

2 A camera is attached to the wrist of the robot and used as a robot-mounted camera. (Fig. 2.3.1.1(b))
  This configuration is supported when the position and orientation of a workpiece are fixed, when the workpiece is shifted only in the translational direction parallel to the machined surface or around in the direction vertical to the machined surface, or when the size of a machined surface is large.

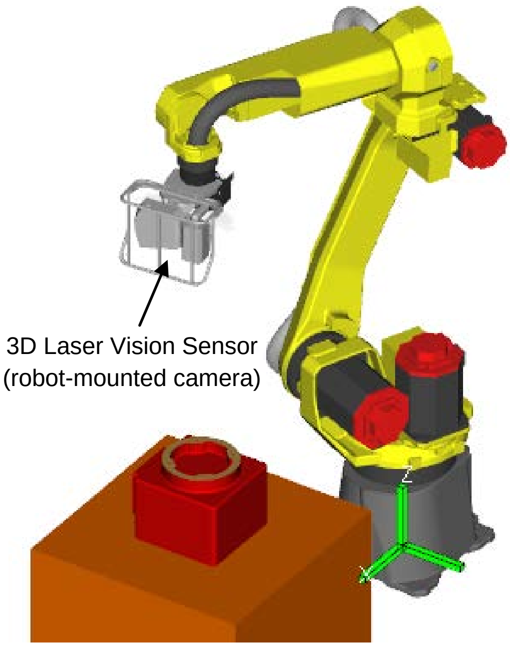


Fig. 2.3.1.1(a) 3D Laser Vision Sensor is attached to the wrist of the robot

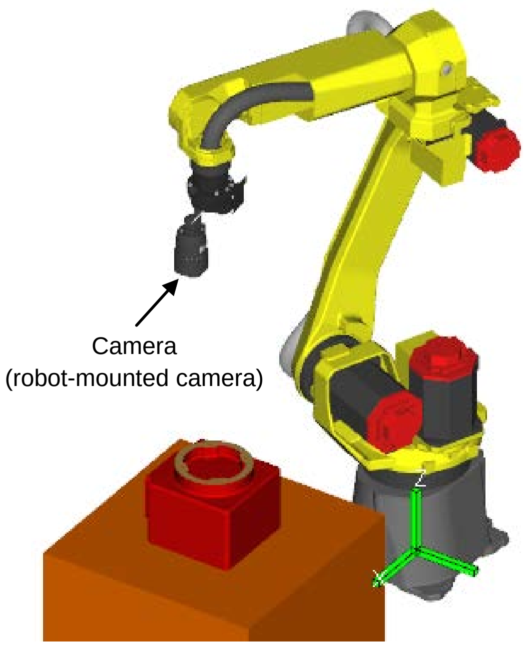


Fig. 2.3.1.1(b) Camera is attached to the wrist of the robot

3 A camera is fixed and used as a fixed camera. (Fig. 2.3.1.1(c))
This configuration is supported only when the following conditions are all satisfied.

- There is only one machined surface on the workpiece and its size is small.
- The position and orientation of the workpiece are fixed, or the workpiece is shifted only in the translational direction parallel to the machined surface or around in the direction vertical to the machined surface.

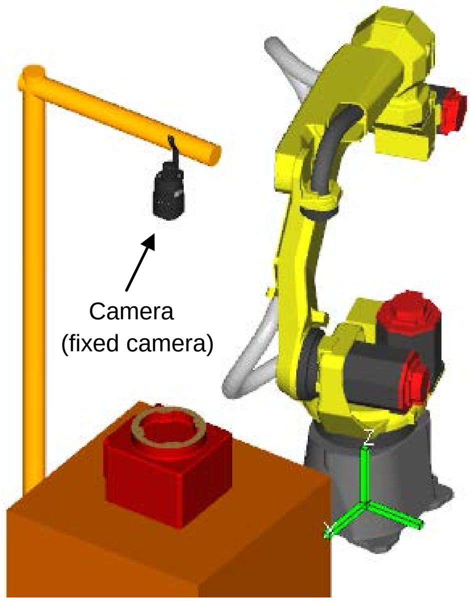


Fig. 2.3.1.1(c) Camera is fixed

2.3.1.2 3D Laser Vision Sensor and camera

This package uses the 3D Laser Vision Sensor or a camera. Usually, the 3D Laser Vision Sensor is used, but some applications may use a camera.
For both the 3D Laser Vision Sensor and a camera, a digital camera or analog camera may be used. When a digital camera is used, the image size can be changed.

3D Laser Vision Sensor

- Measures the positions of targets and edges on a workpiece three-dimensionally.
- Attached to the wrist of the robot and used as a robot-mounted camera.
- Functions not only as the 3D Laser Vision Sensor but also as a camera.

Camera

- Measures the positions of targets and edges on a workpiece two-dimensionally. This can only be used when the targets are shifted two-dimensionally on a specific plane.
- Attached to the wrist of the robot or fixed.

2.3.1.3 Robot-mounted camera and fixed camera

The 3D Laser Vision Sensor and a camera can be installed either as a robot-mounted camera or as a fixed camera. The deburring package usually uses them as a robot-mounted camera, but some applications may use them as a fixed camera.

Robot-mounted camera

- The 3D Laser Vision Sensor or a camera is attached to the wrist of the robot.
- By moving the robot, the 3D Laser Vision Sensor or a camera can divide the entire workpiece and measure it.
- In consideration of the size of the view area, the position and length of an edge, and the like, ROBOGUIDE automatically determines the robot position and number of images to take.
- Since the camera cable moves frequently, care must be taken to cable processing.

Fixed camera

- The fixed camera can be used when the entire workpiece is relatively small to fit in the camera view area and when the plane of the edge to deburr does not incline.
- The coordinate system must be set on the plane of edge to deburr before deburring the workpiece.
- The camera is fixed on the stand etc. to detect a workpiece.
- The camera always views the same place from the same distance.
- The stand of the camera must have enough strength so as not to vibrate the camera or change the camera position.

2.3.2 Selecting a Light

The *i*RVision Deburring Line Output function takes advantages of the visual contrast between the machining plane and the casted surface to find an edge. For that purpose, an appropriate light (a direct Ring Light or Bar Light is recommended) must be selected with respect to the machining plane to uniformly light the wide range of the machined surface of a workpiece. Select a light so that a clearly identifiable image between light and dark can be obtained as shown below.

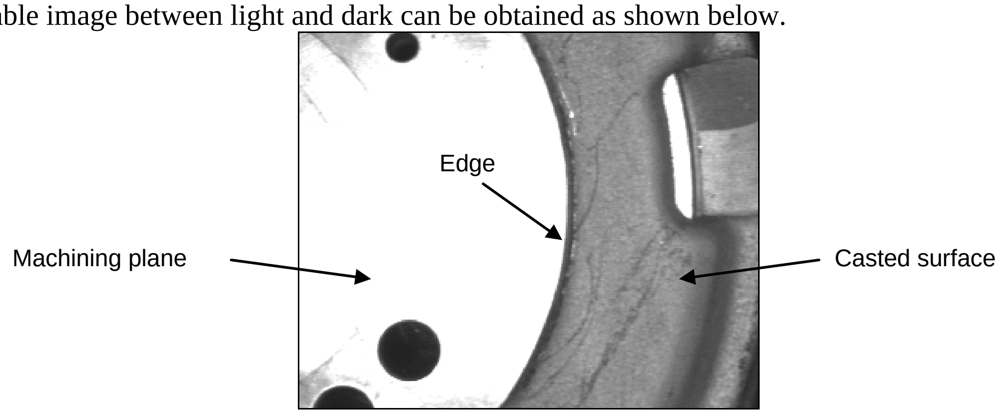


Fig. 2.3.2 Selecting a light

2.4 REQUIRED SOFTWARE OPTIONS

To use this package, the following software options are required.

ROBOGUIDE

- ROBOGUIDE Basic
- ChamferingPRO
- Vision PC option

ROBOT controller

- Force Control Deburring package
  It includes the following functions.
  - Force Control Basic function
  - Force Control Contouring function
  - Force Deburring function (Deburring Path Auto Generation)
  - *i*RVision 2D Single-View Vision Process
  - *i*RVision 3DL Single-View Vision Process
  - *i*RVision Deburring Line Output Vision Process

2.5 SCOPE

The scope of this package is as shown below.

- This package can only be used for robot models in which the force control function is supported.
- This package can only be used in system configurations without additional axes.
- Machined burrs between the machining plane and the casted surface are subjected.
- The deburring tool always moves left to its pushing direction.
- Burrs themselves are not detected by the vision sensor and deburred, but burrs are deburred in a batch to a predetermined edge.
- The following burrs are not supported.
  - Casted burrs
  - Machined burrs between machined surfaces
  - Machined burrs having a length of 20 mm or shorter
  - Machined burrs on the 3D curved surface

3 OFFLINE TEACHING WITH ROBOGUIDE

Before executing deburring with an online robot, it is necessary to perform an offline teaching with ROBOGUIDE to generate data files (including edge data and TP programs which detect edges).
This chapter describes the offline teaching procedures by using ROBOGUIGE based on the flow shown in Fig. 3.
When there are multiple types of parts (workpieces), repeat operations in steps 2 to 5 for each type of part.

1 Create a workcell.
2 Add a part.
3 Select an edge.
4 Set targets.
5 Generate data files and transfer them to the online robot controller.

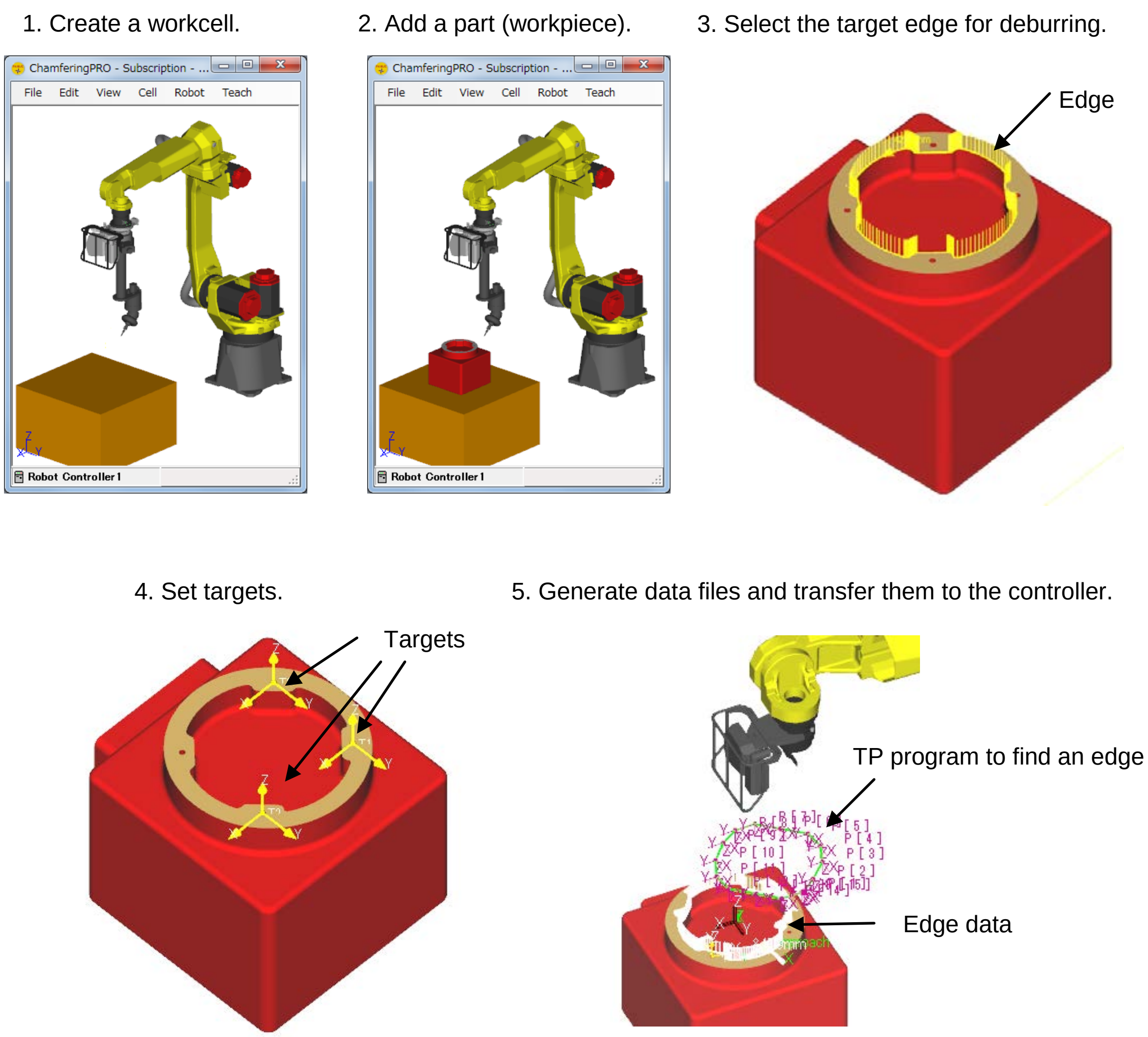


Fig. 3 Offline teaching with ROBOGUIDE

3.1 CREATING A WORKCELL

Create a workcell of a deburring system having a configuration as shown in Fig. 3.1 according to the following procedures:

1 Create a new workcell.
2 Add a force sensor.
3 Add a deburring tool.
4 Set the default values for edge parameters.
5 Add a vision sensor.
6 Add a fixture.

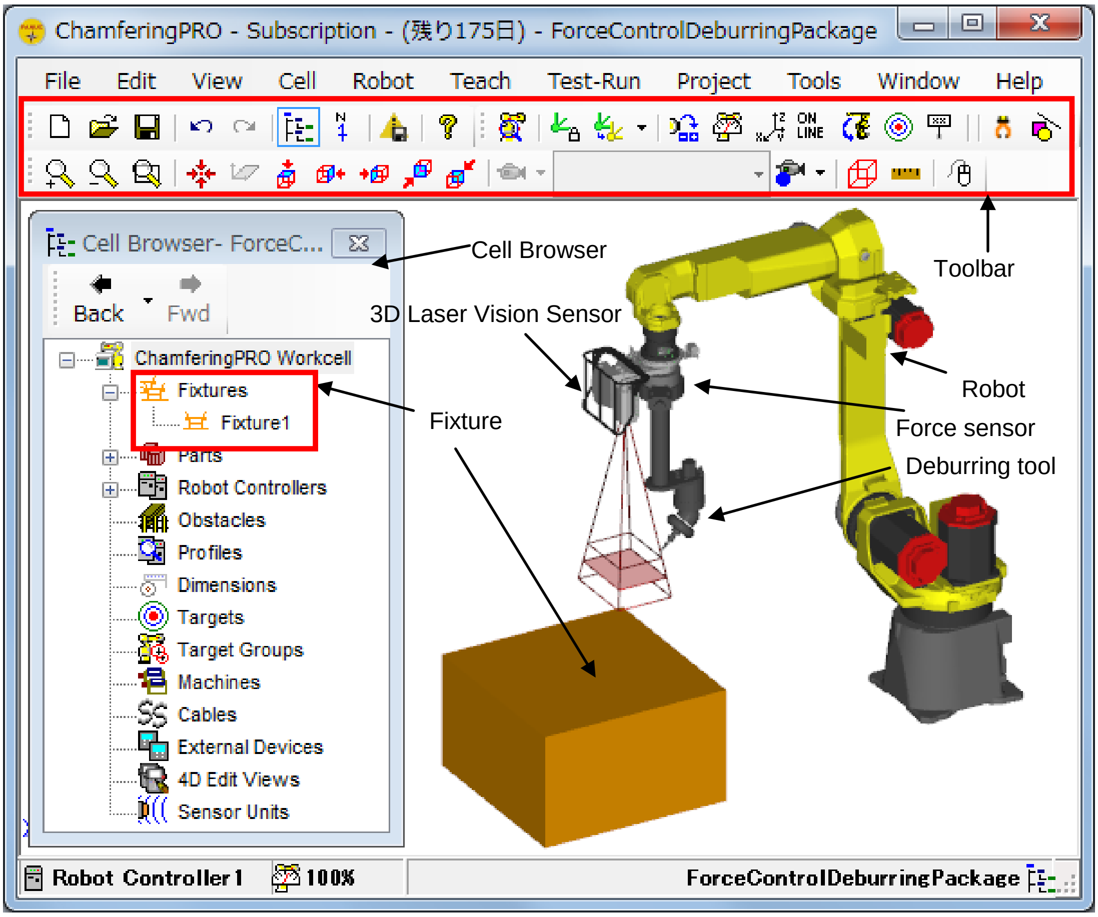


Fig. 3.1 Sample workcell of a deburring system

TIPS
1 Place the robot, fixture, deburring tool, force sensor, and vision sensor according to the actual deburring system.
2 On the toolbar, press the "Show/Hide Cell Browser" button , "Show/Hide Target Tools" button , and "Draw features on parts" button to display the Cell Browser window, Target tool, and CAD to Path Quickbar, respectively.
3 Select "Property" from the right-click menu for an item such as a fixture to display the property page for the item.

3.1.1 Creating a New Workcell

Create a new workcell according to the following procedures:
1 Start ChamferingPRO and click the "New Cell" button on the toolbar. The "Workcell Creation Wizard" window (Fig. 3.1.1(a)) appears. Enter a workcell name in "Name" and click the "Next" button.

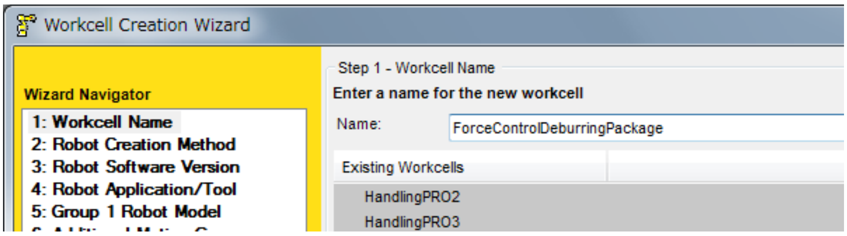


Fig. 3.1.1(a) Entering a workcell name

2 On the Robot Creation Method selection window (Fig. 3.1.1(b)), select "Create a new robot with the default ChamferingPRO config." and click the "Next" button.

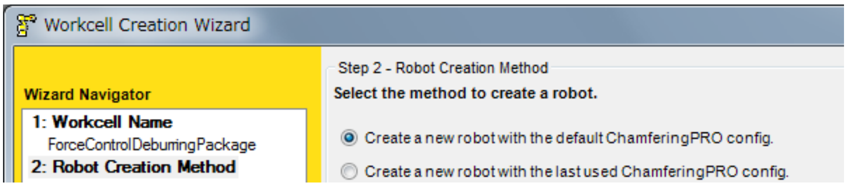


Fig. 3.1.1(b) Selecting a robot creation method

3 On the Robot Software Version selection window (Fig. 3.1.1(c)), select "V8.10" or "V8.20" or "V8.30" and click the "Next" button.

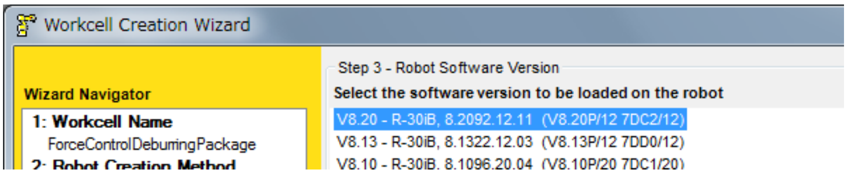


Fig. 3.1.1(c) Selecting a robot software version

4 On the Robot Application/Tool selection window (Fig. 3.1.1(d)), select "HandlingTool (H552)" or "LR HandlingTool(H551)" and click the "Next" button.

Fig. 3.1.1(d) Selecting a robot application/tool

5 On the Group 1 Robot Model selection window (Fig. 3.1.1(e)), select a robot model (for example, Robot H780 M-10*i*A(Ver.2)) and click the "Next" button.

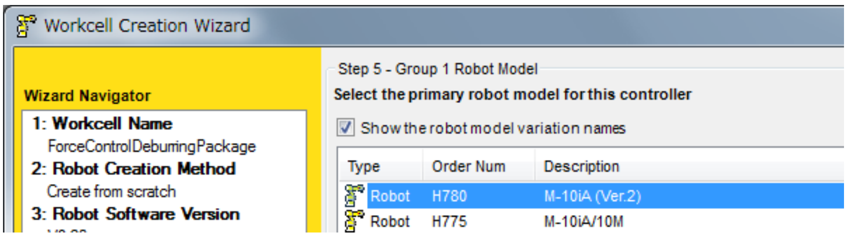


Fig. 3.1.1(e) Selecting a Group 1 robot model

6 On the Additional Motion Groups selection window, select no item and click the "Next" button.

7 On the Robot Options selection window (Fig. 3.1.1(f)), select "FC Deburring package (J840)" and click the "Next" button.

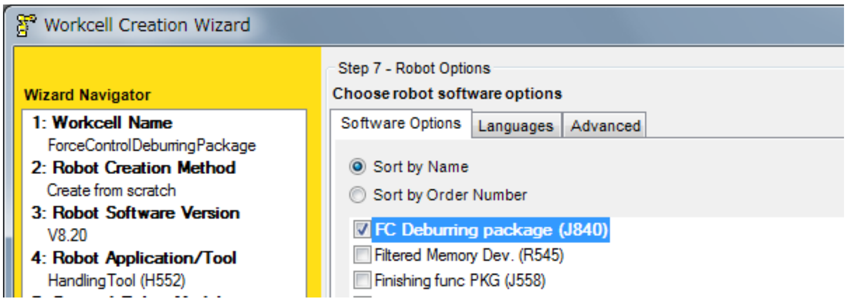


Fig. 3.1.1(f) Selecting a robot option

8 On the Summary window (Fig. 3.1.1(g)), check the summary of the workcell. When the selections are all correct, click the "Finish" button to generate a Virtual Robot Simulator.

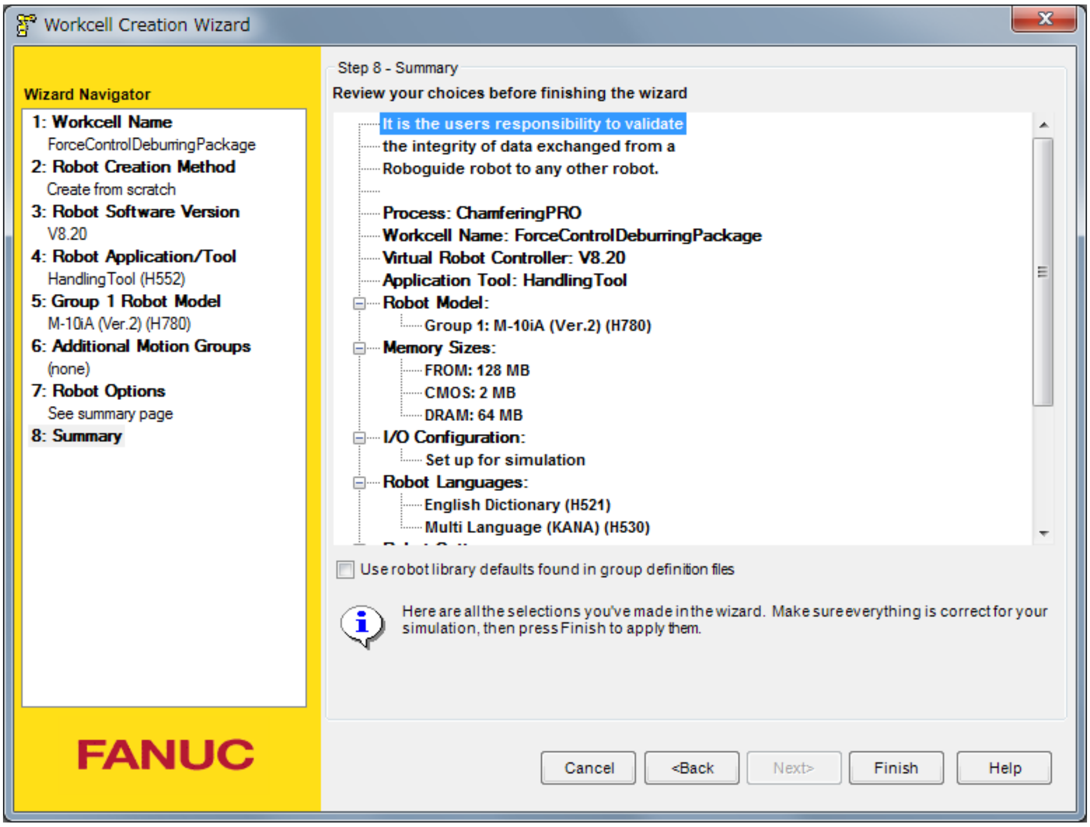


Fig. 3.1.1(g) Checking the summary

9 When a setting window as shown in Fig. 3.1.1(h) appears during the generation of the Virtual Robot Simulator, set an item according to the actual robot to be used.

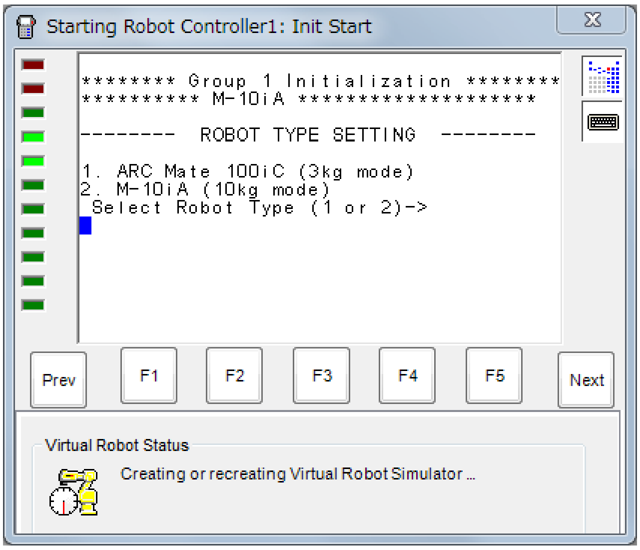


Fig. 3.1.1(h) Virtual Robot Simulator setting

10 When the Virtual Robot Simulator has been generated, a new workcell is started (Fig. 3.1.1(i)) and a robot is added to the workcell.

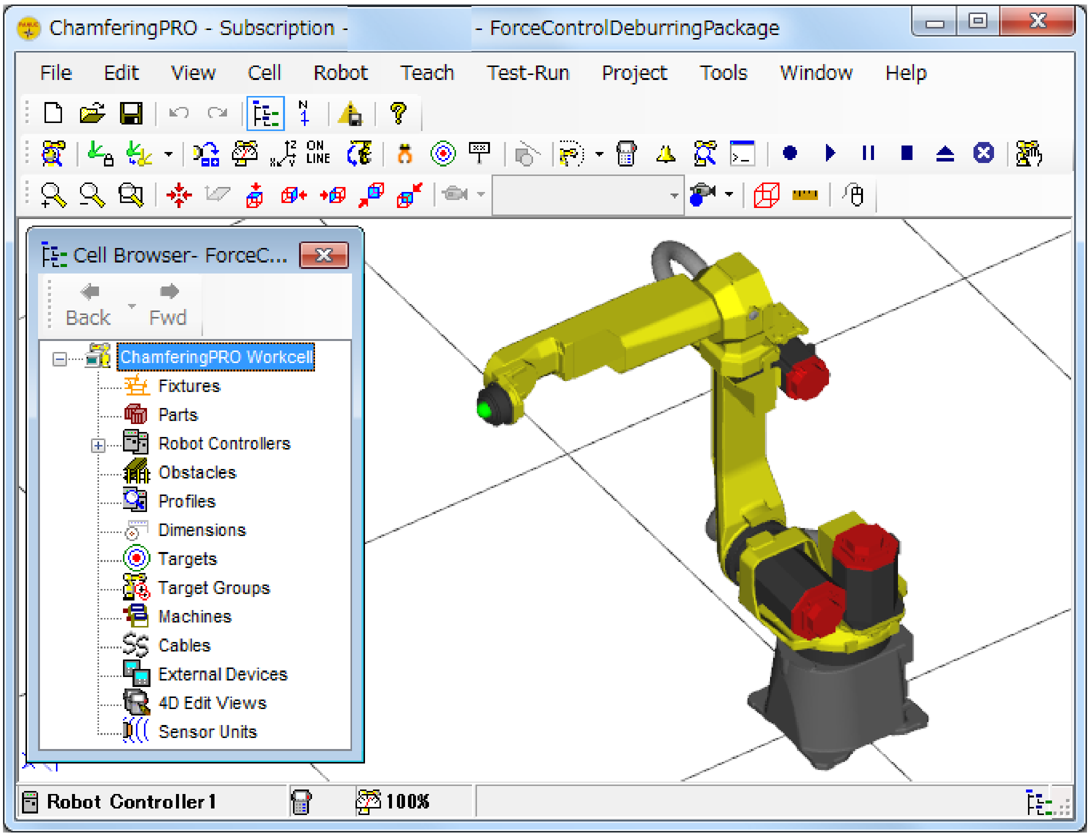
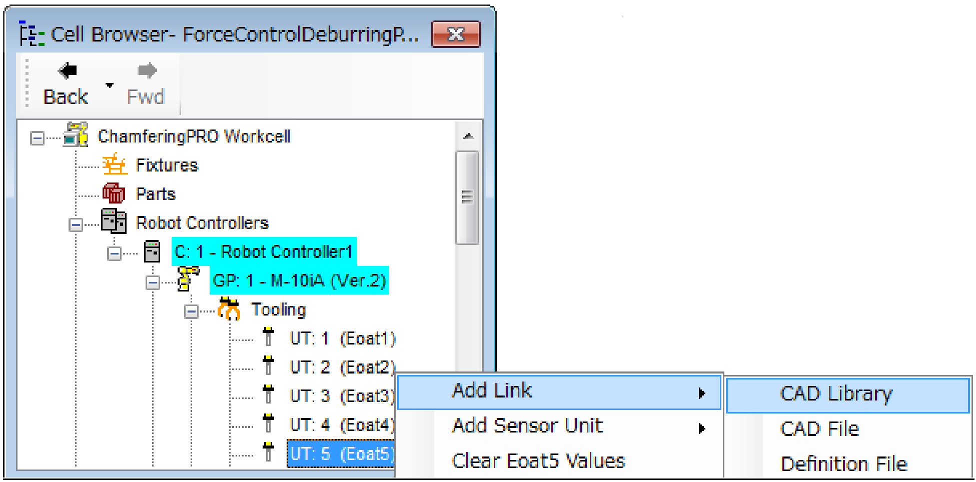


Fig. 3.1.1(i) New workcell

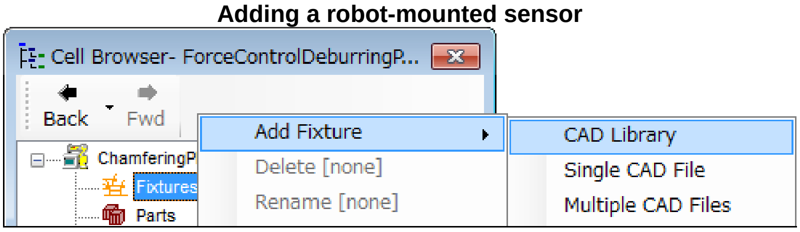
3.1.2 Adding a Force Sensor

Add a force sensor (for example, FS-15*i*A with an adapter) according to the following procedures:

1 On Cell Browser, expand "Tooling" and right-click "UT:5" ("Fixtures" for a fixed sensor). From the displayed right-click menu, select "Add Link" ("Add Fixture" for a fixed sensor) → "CAD Library" (Fig. 3.1.2(a)). On the "Image Librarian" window, select "Others" → "ForceSensor" → "FS-15*i*A_H614" or another item. (Fig. 3.1.2(b))



Adding a robot-mounted sensor



Adding a fixed sensor

Fig. 3.1.2(a) Adding a force sensor

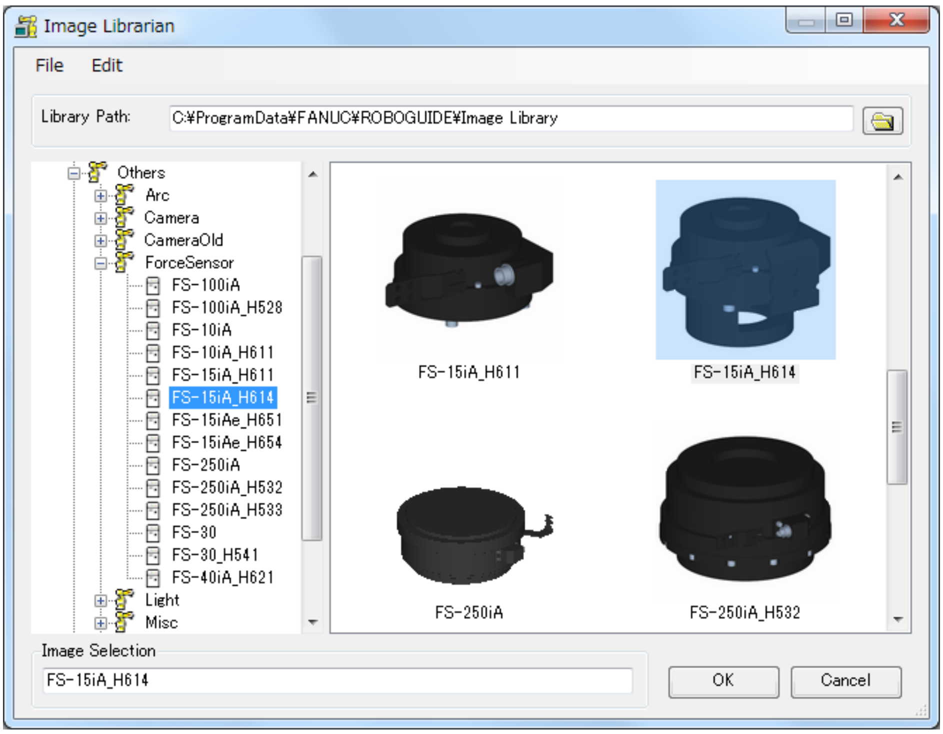


Fig. 3.1.2(b) Selecting a force sensor model

2 A link to the force sensor is added to the workcell (Fig. 3.1.2(c)). The link is displayed by selecting "Tooling" → "UT:5" ("Fixtures" for a fixed sensor) on Cell Browser.

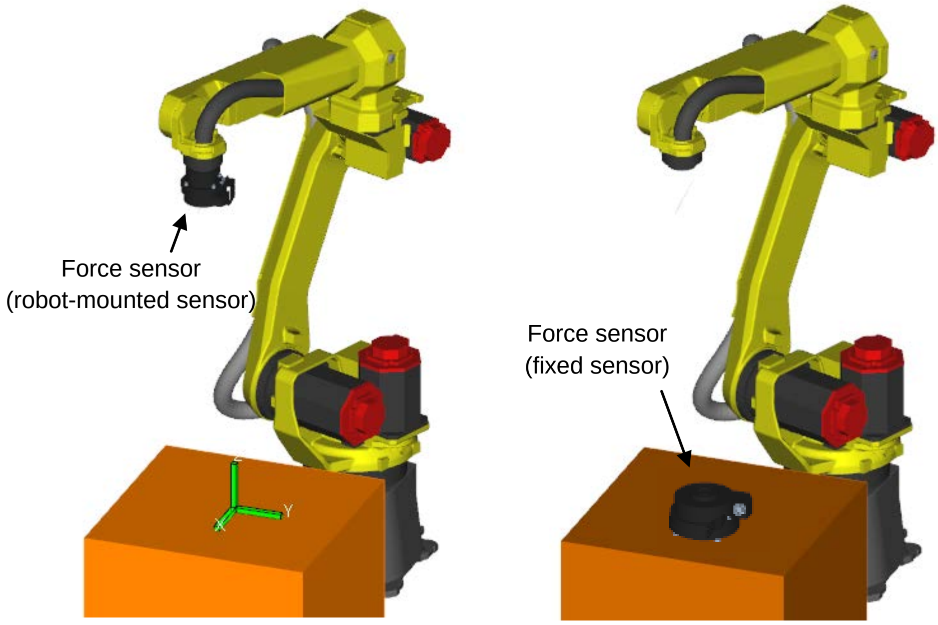
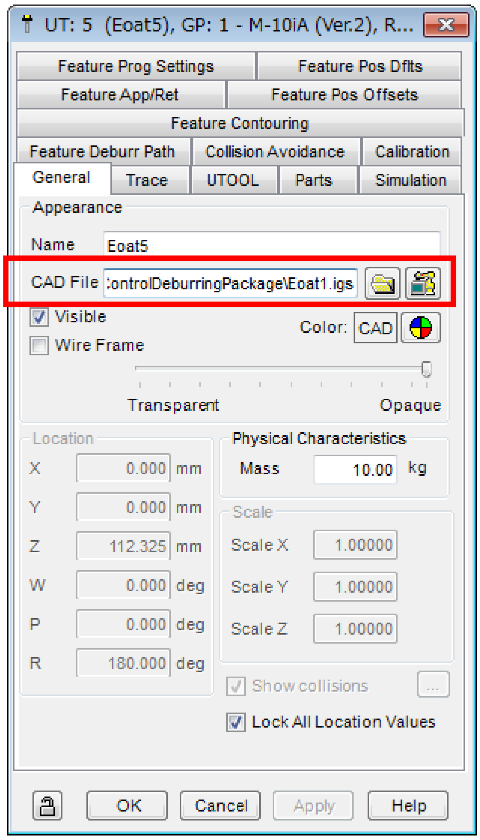


Fig. 3.1.2(c) Added a force sensor

3.1.3 Adding a Deburring Tool

Add a deburring tool according to the following procedures. Specify the tool mounting position according to the actual deburring system.

1 On Cell Browser, click "Tooling" and right-click "UT:5". From the displayed right-click menu, select "Property" to open the property page of the tool (Fig. 3.1.3(a)). Select the CAD model of the tool for "CAD File" on the "General" tab and click the "Apply" button to add the deburring tool to tool frame "UT:5" (Fig. 3.1.3(b)).
You can change the location of the added deburring tool by specifying a desired location for "Location" on the "General" tab. When the location of the tool is changed, however, the locations of all links and vision sensors added to this tool frame are also changed.



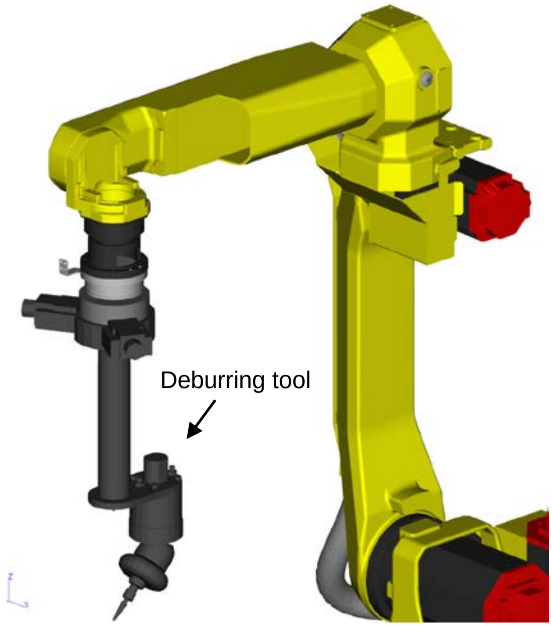


Fig. 3.1.3(a) Adding a tool and adjusting its location **Fig. 3.1.3(b) Added deburring tool**

2 On the UTOOL tab (Fig. 3.1.3(c)) of the tool property page, edit the tool frame. Teach the tool frame so that the tool frame Z axis is normal to the machining plane and the -Z axis is located in a direction away from the machining plane. (Fig. 3.1.3(c))

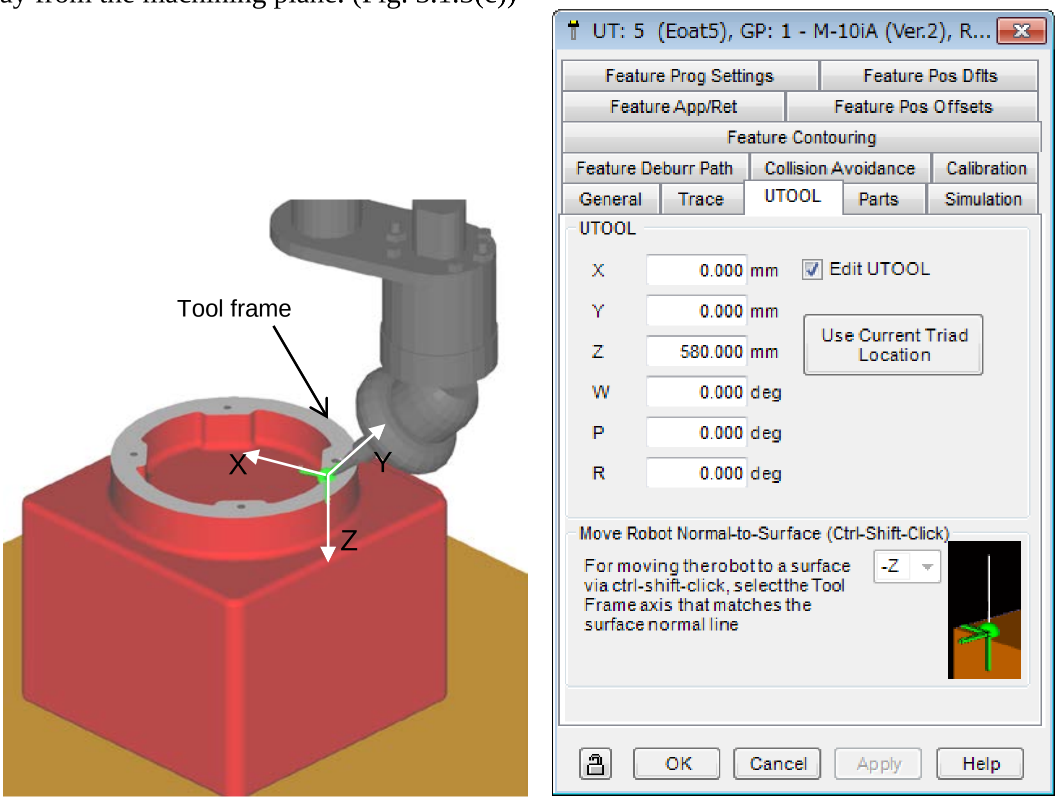


Fig. 3.1.3(c) Setting the tool frame

The position of the origin of the tool frame (Fig. 3.1.3(d)) changes depending on the setting of "Orientation Handling" on the "Feature Pos Dflts" tab. For details of "Orientation Handling", see Subsection 3.1.4.1, "Setting position defaults".

- When "Fixed tool spin, keep normal" is selected: Teach the TCP of the tool as the origin of the tool frame.
- When "Change tool spin along path, keep normal" is selected: Teach the contact point of the tool and workpiece as the origin of the tool frame.

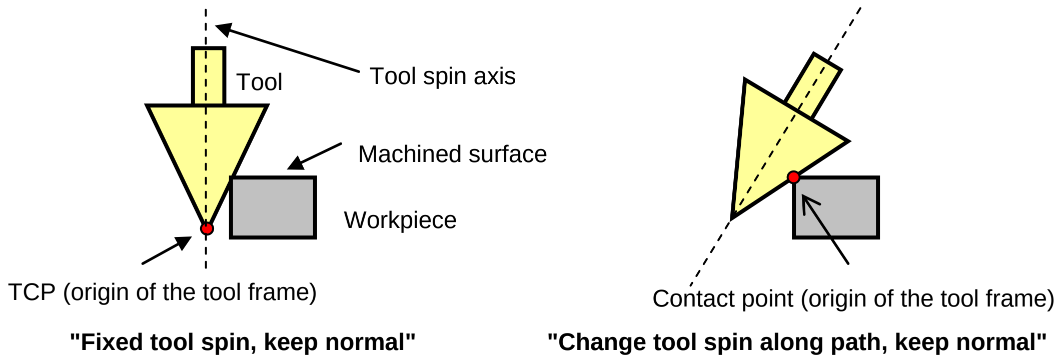


Fig. 3.1.3(d) Position of the origin of the tool frame

3.1.4 Setting the Default Values for Edge Parameters

You can set the default values for edges (features) defined on the CAD model of a workpiece on the following four tabs of the tool property page:

- Feature Pos Dflts
- Feature App/Ret
- Feature Deburr Path
- Feature Contouring

> ⚠ **CAUTION**
> 1 The values set on the tool property page are used as the default values when an edge is defined.
> 2 Be sure to set the items on the "Feature Pos Dflts" and "Feature App/Ret" tabs.
> 3 Set items on the "Feature Deburr Path" and "Feature Contouring" tabs as required.
> 4 This function uses Force Control Schedule [10] by default. Change the schedule number on the "Feature Contouring" tab when required.

3.1.4.1 Setting position defaults

On the "Feature Pos Dflts" tab of the tool property page, set position defaults in the tool pushing direction as shown in the figure below. (Fig. 3.1.4.1(a))

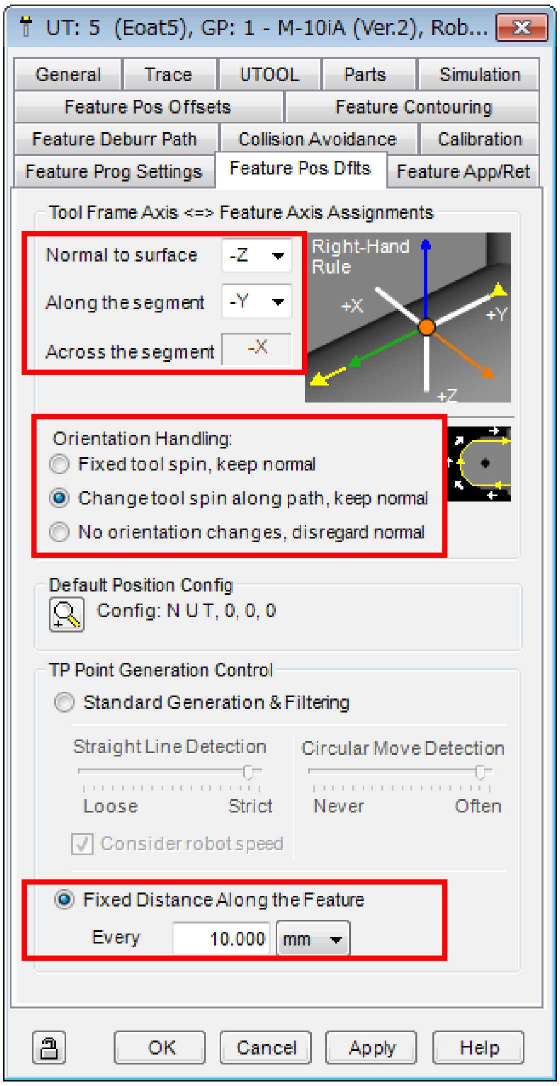
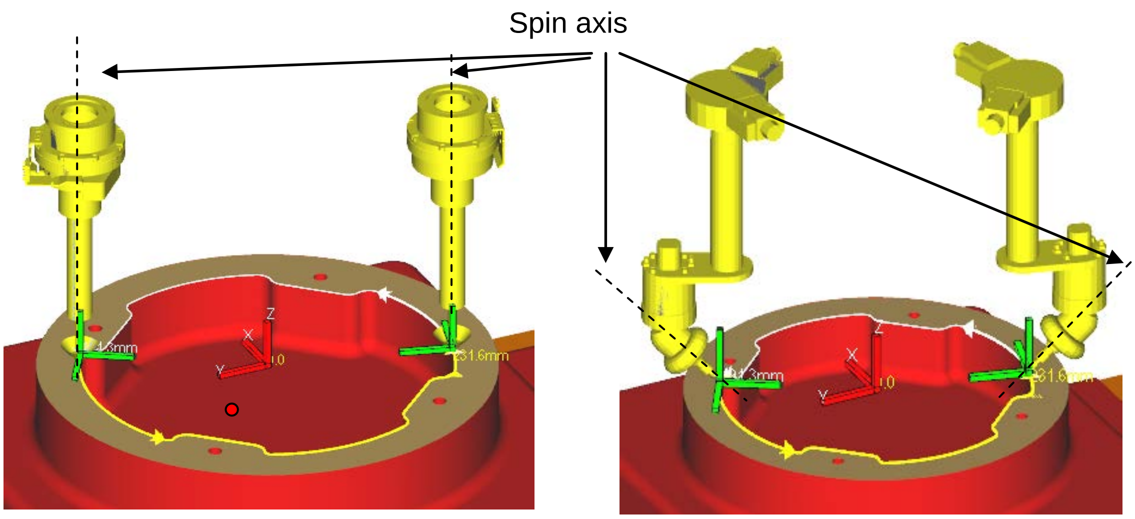


Fig. 3.1.4.1(a) Setting values on "Feature Pos Dflts"

1 Normal to surface: -Z
2 Select an item for "Orientation Handling" according to the tool spin axis. (Fig. 3.1.4.1(b))



"Fixed tool spin, keep normal" **"Change tool spin along path, keep normal"**

Fig. 3.1.4.1(b) "Orientation Handling" settings

> ⚠ **CAUTION**
> For all edges of a workpiece, the same value must be set for "Orientation Handling".

3 Along the segment: Only when "Change tool spin along path, keep normal" is selected for "Orientation Handling", and you want to adjust the orientation of the deburring tool using ROBOGUIDE (Subsection 3.3.2, "Adjusting the Orientation of the Deburring Tool") or to simulate deburring (Appendix B, "SIMULATING DEBURRING OPERATIONS WITH ROBOGUIDE"), set a value according to the tool pushing direction in the tool frame as described below. For other cases, you do not need to set any value for "Along the segment".

- When the pushing direction is +X, set -Y for "Along the segment".
- When the pushing direction is -X, set +Y for "Along the segment".
- When the pushing direction is +Y, set +X for "Along the segment".
- When the pushing direction is -Y, set -X for "Along the segment".

4 Select "Fixed Distance Along the Feature" and set a distance (10 mm by default) according to the dimension of the edge. Generally, you do not need to change the distance. When the minimum curvature radius of an edge corner is shorter than 10 mm, set the minimum curvature radius of the corner for the distance.
The distance set in this field is used as the distance between points of edge data used by the *i*RVision Deburring Line Output Vision Process. The distance does not mean the distance between teaching points of the generated deburring program.

3.1.4.2 Setting approach and retreat points

On the "Feature App/Ret" tab of the tool property page, select "Add approach point" and set a negative value (for example, -10 mm) for Acr under "Approach Point". Set 0 for other than Acr. You do not need to set "MoType" or any item under "Retreat Point". (Fig. 3.1.4.2(a))

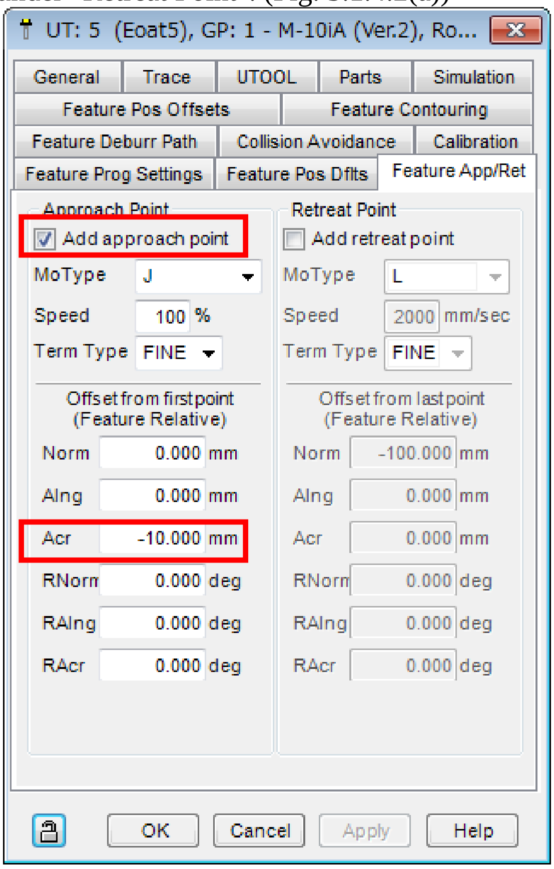


Fig. 3.1.4.2(a) Adding a feature approach point

For this Acr value, the approach point is indicated by an X value in the user frame for the edge. For example, when the Acr value is set to -10, the approach point of the drawn edge is as shown in Fig. 3.1.4.2(b). For details of how to draw an edge, see Subsection 3.3.1, "Drawing an Edge". For details of the user frame of the edge, see Subsection 3.3.1.1, "User frame set for each edge".

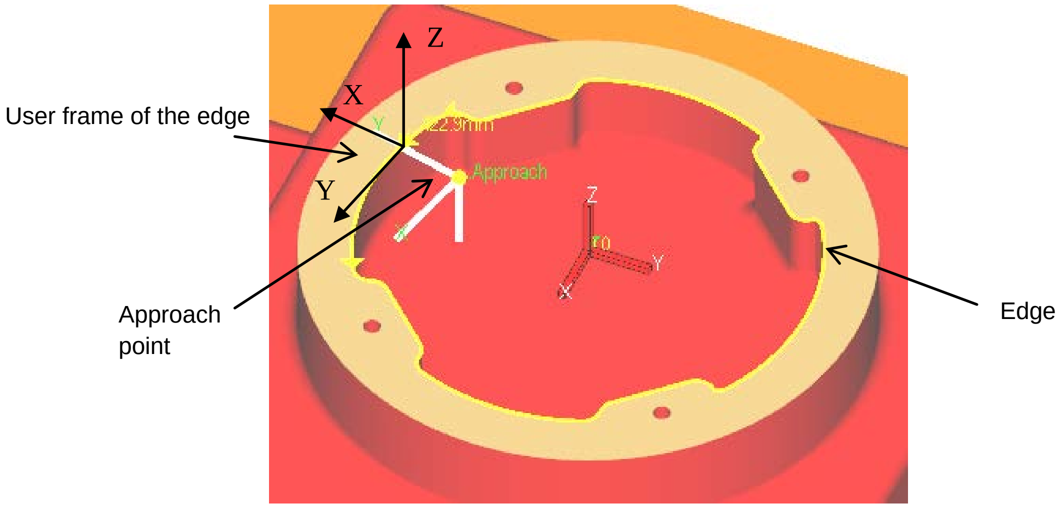


Fig. 3.1.4.2(b) Position of an approach point

For details of other items on this tab, refer to the ROBOGUIDE Online Help.

3.1.4.3 Setting deburr path generation

On the "Feature Deburr Path" tab of the tool property page, set parameters for generating a TP program (DU_{Part Name}_{Edge Index}.TP) with point sequence information of each detected edge. (Fig. 3.1.4.3(a)) For details, see Chapter 5, "ONLINE RUNNING ON THE ROBOT" and Appendix C, "SAMPLE TP PROGRAMS".
You can use the default values as is on ROBOGUIDE. When an appropriate value is known for the online robot, you can set the value on this tab.

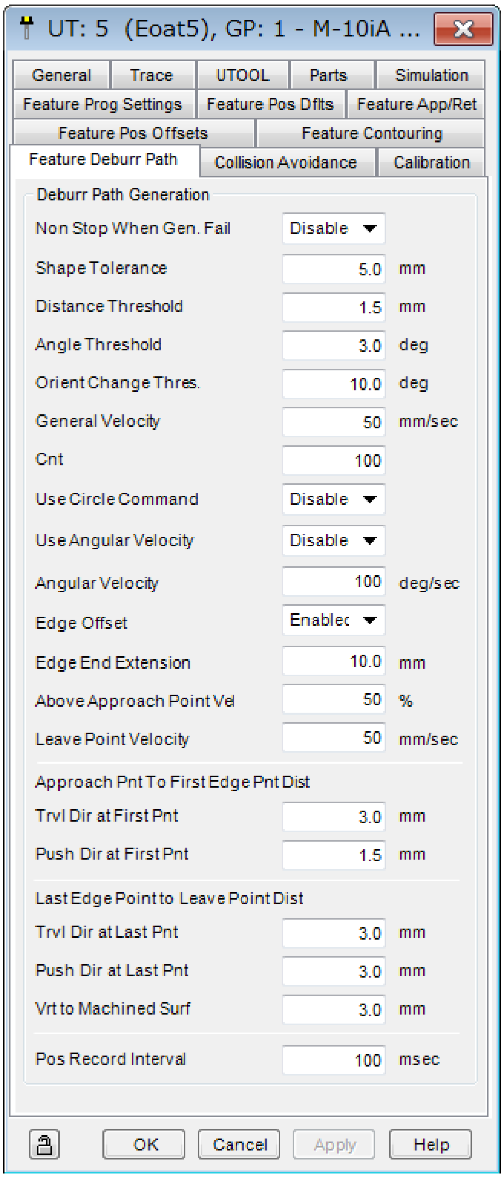


Fig. 3.1.4.3(a) "Feature Deburr Path" tab of the tool property page

Non Stop When Gen. Fail

Set whether the robot stops if the generation of the deburring path for an edge fails.

- Disable: If the generation of the deburring path for an edge fails, an alarm is issued and the robot stops.
- Enable: If the generation of the deburring path for an edge fails, a dummy path for the edge is generated and the robot does not stop. If the edge is closed, the dummy path for the edge contains only the point above the start point of the edge. If the edge is not closed, the dummy path for the edge contains only the points above the start and end points of the edge.

Default value: Disable

Shape Tolerance

Maximum allowable difference between the actual edge and CAD model shape. When the difference between the actual edge and CAD model shape is greater than this value, the *i*RVision Deburring Line Output Vision Process cannot detect the edge.

Default value: 5.0 mm

Distance Threshold

Parameter related to the minimum distance between adjacent teaching points for a deburring path.

- When "Disabled" is selected for "Use Angular Velocity" described later, this value indicates the minimum distance between adjacent teaching points for a deburring path.
- When "Enabled" is selected for "Use Angular Velocity" described later, the distance between adjacent teaching points for a deburring path may be smaller than this value in a corner.

The smaller this value is, the more teaching points are set for a deburring path in a curve of an edge so that the deburring path becomes closer to the actual workpiece shape.
When this value is small, the teaching velocity on the automatically generated deburring path may be lower than "General Velocity" described below.
Default value: 1.5 mm

Angle Threshold

Minimum angle made by three contiguous teaching points for a deburring path.
When this parameter is set, teaching points are set only at both ends in a linear section.
The smaller this value is, the more teaching points are set for a deburring path in a curve of an edge so that the deburring path becomes closer to the actual workpiece shape.
Default value: 3.0 deg

Orient Change Threshold

Minimum variation between the orientation angles of two contiguous teaching points for a deburring path.
This parameter is valid only when "Enabled" is selected for "Use Angular Velocity" described later.
The smaller this value is, the more teaching points are set for a deburring path in a curve of an edge so that the deburring path becomes closer to the actual workpiece shape.
Default value: 10.0 deg

General Velocity

Maximum teaching velocity for teaching points for a deburring path. This velocity is used in the deburring path automatically generated.
When a large value is set for this parameter, the deburring depth becomes small. When a small value is set for this parameter, the deburring depth becomes great.
When a small value is set for "Distance Threshold", the teaching velocity on the automatically generated deburring path may be lower than the velocity set for this parameter.
Default value: 50 mm/sec

Cnt

Cnt value for teaching points for a deburring path. This value is used in the deburring path automatically generated.
When a workpiece edge has an acute angle or the curvature radius in a corner is small (up to 3 mm), set a small value for this parameter (for example, 85). A too small value may affect the actual general velocity of the robot, however.
Default value: 100

Use Circular Command

This switch parameter specifies whether to use a circular command in a move statement for a corner. (This function automatically determines whether a section is a corner.)

- Disabled: Uses a linear command for all teaching points.
- Enabled: Uses a circular command in a move statement for a corner.

Default value: Disabled

Use Angular Velocity

This switch parameter specifies whether to use an angular velocity in a move statement for a corner. (This function automatically determines whether a section is a corner.)

- Disabled: Does not use an angular velocity in a move statement for a corner.
- Enabled: Uses an angular velocity in a move statement for a corner.

Default value: Disabled

Angular Velocity

Angular velocity set in a move statement for a corner. This velocity is used in the deburring path automatically generated.
When "Enabled" is selected for "Use Angular Velocity" and the orientation of the tool greatly changes in a corner, use this parameter.
Default value: 100 deg/sec

Edge Offset

This switch parameter determines whether to allow the deburring path move away from the actual workpiece edge (set an offset).

- When "Enabled" is selected, an offset is set. The offset amount is the component of "Push dir at First Pnt" of the "Approach Pnt To First Edge Pnt Dist" described below. (Fig. 3.1.4.3(b))
- When "Disabled" is selected, no offset is set. The deburring path coincides with the actual workpiece edge. (Fig. 3.1.4.3(c))

Default value: Enabled

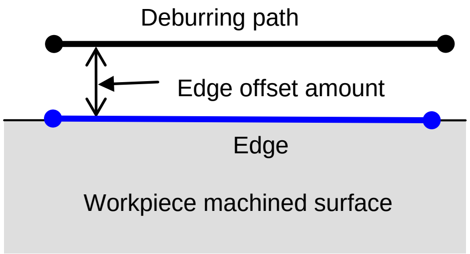


Fig. 3.1.4.3(b) Edge Offset: Enabled

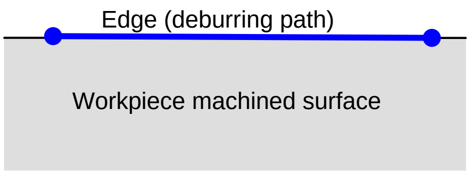


Fig. 3.1.4.3(c) Edge Offset: Disabled

Edge End Extension

Length of the extension from the last edge point of a closed edge. (Fig. 3.1.4.3(e))
When this length is set to 0 for a closed edge or when an edge is not closed, no extension is added. (Fig. 3.1.4.3(d))
Default value: 10.0 mm

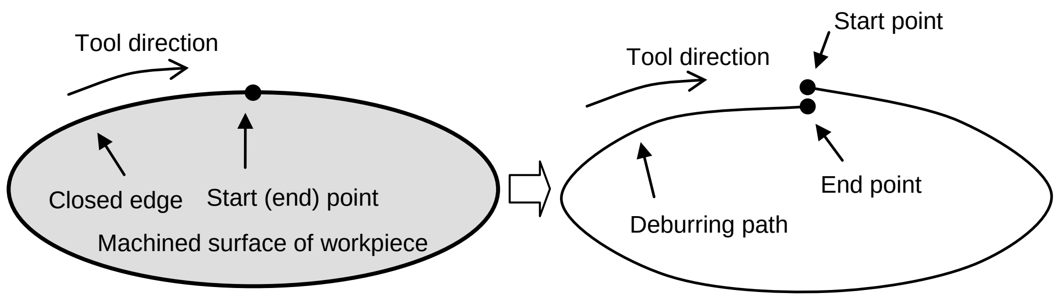


Fig. 3.1.4.3(d) No extension from the end point

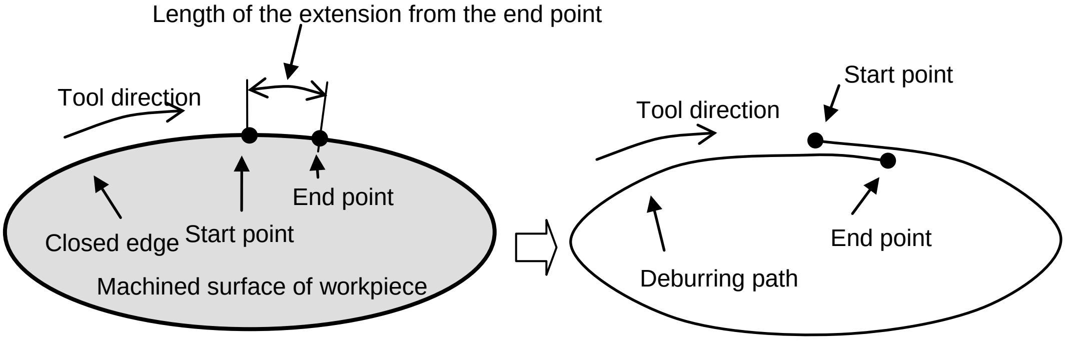


Fig. 3.1.4.3(e) Extension from the end point

Above Approach Point Vel
Joint velocity used during the movement to the point above the approach point for contouring. This velocity is used in an automatically generated deburring path. The linear velocity used during the movement to the point above the leave point is also calculated from this value.
Default value: 50 %

Leave Point Velocity
The velocity used during the movement to the leave point for contouring. This velocity is used in an automatically generated TP program.
Default value: 50 mm/sec

Approach Pnt To First Edge Pnt Dist

Trvl Dir at First Pnt
Component in the travelling direction at the first edge point of the distance from the approach point to the edge start point. (Fig. 3.1.4.3(f))
Default value: 3.0 mm

Push Dir at First Pnt
Component in the pushing direction at the first edge point of the distance from the approach point to the edge start point. (Fig. 3.1.4.3(f))
Default value: 1.5 mm

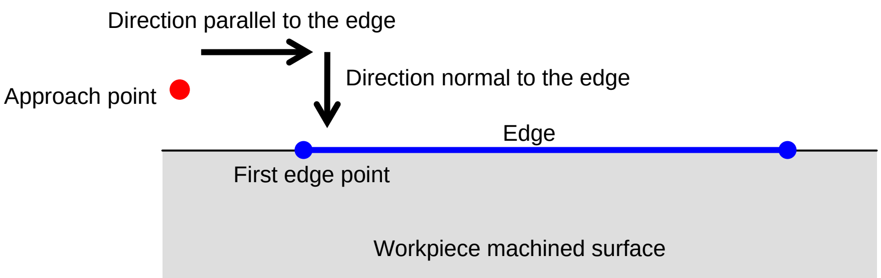


Fig. 3.1.4.3(f) Distance from the approach point to the edge start point

Last Edge Point to Leave Point Dist

Trvl Dir at Last Pnt
Component in the travelling direction at last edge point of the distance from the last edge point to the leave point. (Fig. 3.1.4.3(g))
Default value: 3.0 mm

Push Dir at Last Pnt
Component in the pushing direction at last edge point of the distance from the last edge point to the leave point. (Fig. 3.1.4.3(g))
Default value: 3.0 mm

Vrt to Machined Surf
Component in the direction normal to the machined surface of the distance from the last edge point to the leave point. (Fig. 3.1.4.3(g))
Default value: 3.0 mm

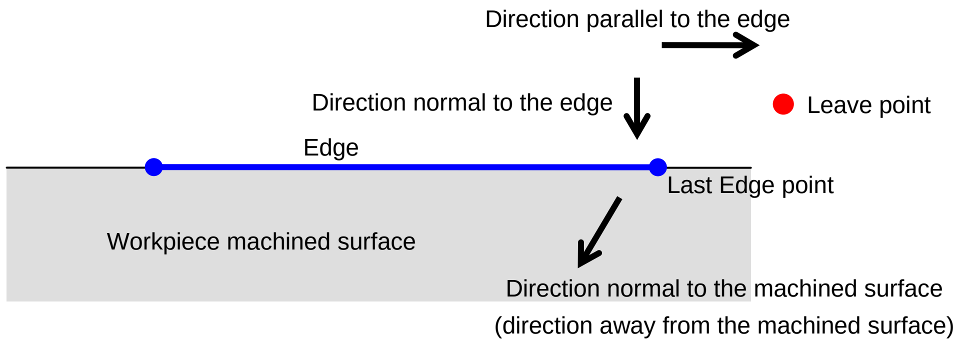


Fig. 3.1.4.3(g) Distance from the last edge point to the leave point

Pos Record Interval

Position recording time interval. This interval is used only when the edge data files are updated in the robot. For the update of data files, see Subsection A.2.1, "If the Shapes of the Actual Workpiece and the CAD Model Differ Greatly" in Appendix A.

- When a large value is set for the interval, a small number of positions are recorded for the same edge.
- When a small value is set for the interval, a large number of positions are recorded for the same edge.

Default value: 100 msec

TIPS

Examples of setting parameters are shown below:

1. When the shape difference between workpieces is greater than 5 mm, set a large value for "Shape Tolerance".
2. If you want to adjust the tool’s travelling velocity, adjust "General Velocity".
3. When the amount of deburring is insufficient at the end point of an edge, set a large value for "Edge End Extension".

3.1.4.4 Setting contouring schedule

On the "Feature Contouring" tab of the tool property page, set parameters for a contouring program using force control (DU_{Part Name}_{Edge Index}.TP). (Fig. 3.1.4.4) For details, see Chapter 5, "ONLINE RUNNING ON THE ROBOT" and Appendix C, "SAMPLE TP PROGRAMS".
For details of each parameter on the "Feature Contouring" tab, refer to Subsection 3.5.7.6, "Parameters" of "R-30iB/R-30iB Mate CONTROLLER Force Sensor OPERATOR’S MANUAL B-83424EN".
You can use the default values as is on ROBOGUIDE. When an appropriate value is known for the actual robot, you can set the value on this tab.

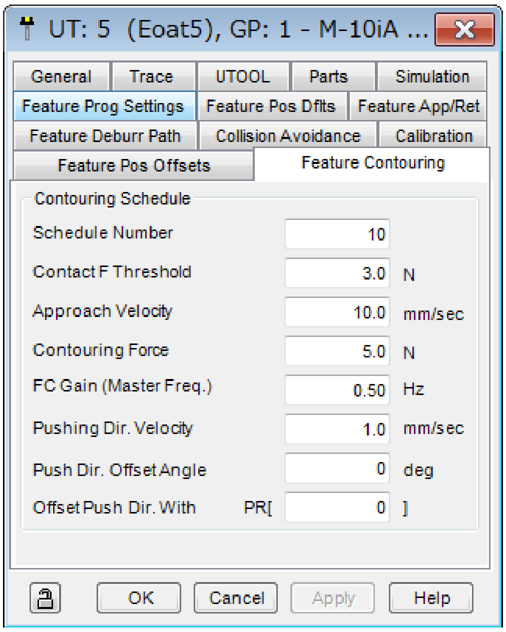


Fig. 3.1.4.4(a) "Feature Contouring" tab of the tool property page

Schedule Number

Set the number of a force control contouring schedule to be used. The specified schedule data must be “Unused”.
Default value: 10

Contact F Threshold

This force threshold is used to determine whether the machining target is touched by the deburring tool. Contouring operation actually starts after the target is touched. Set a value not greater than that set for "Contouring Force".
Default value: 3.0 N

Approach Velocity

The velocity of the deburring tool in the pushing direction until the machining target is touched. When a large value is set, the time until the target is touched can be reduced, but the target may be deburred too much as the force at the moment the target is touched may be greater than the preset Contouring Force as described below.
Default value: 10.0 mm/sec

Contouring Force

Target contouring force for actual contouring operation.
Default value: 5.0 N

FC Gain (Master Freq.)

This parameter determines the responsiveness of force control. When a large value is set, the responsiveness of force control becomes higher, but vibration may occur. When a small value is set, vibration can be suppressed, but the responsiveness during force control is lowered, resulting in slow operation.
Increase this parameter by about 0.1 Hz at a time while checking whether vibration occurs during force control.
Default value: 0.50 Hz

Pushing Dir. Velocity

Velocity command applied in the pushing direction. Generally, setting 0 for this parameter causes no problem. When the curvature factor of the workpiece is large and the tool may move apart from the

workpiece during contouring operation, set a value between 1 mm/sec and 10 mm/sec.
Default value: 1.0 mm/sec

Push Dir. Offset Angle

Specify the angle to be used to change the angle formed by the pushing direction of the tool and the machined surface. If this value is not 0 deg, "Offset Push Dir. With PR" described below needs to be specified to a nonzero number.
Default value: 0 deg

Offset Push Dir. With PR

Specify the number of the position register to be used to change the angle formed by the pushing direction of the tool and the machined surface. This position register is used in the automatically generated deburring path. If "Push Dir. Offset Angle" described above is not 0 deg, this position register number needs to be specified to a nonzero number.
Default value: 0

- If the height difference of the workpiece is small, the tip of the deburring tool may come into contact or collide with the workpiece at the approach point of the deburring path or at the intermediate point of the edge. This may damage the workpiece surface or apply an excessive force to the tool's tip, causing the tool to break. (Fig. 3.1.4.4(b))

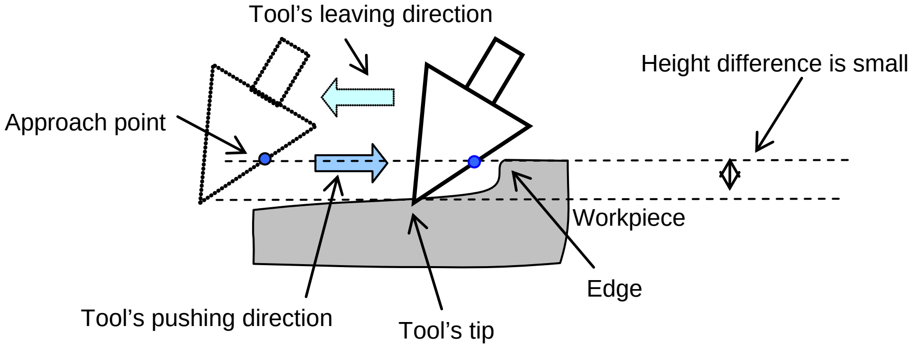


Fig. 3.1.4.4(b) When the tool's pushing direction offset angle is 0 deg

- When "Change tool spin along path, keep normal" is selected, you can specify the angle formed by the pushing direction of the tool and the machined surface. The approach point of the deburring path is taught at a position away from the machined surface, and the pushing direction of the deburring tool becomes diagonal.
  If the height difference of the workpiece is small, the tool does not come into contact with the workpiece at the start point of the edge. Also, if the deburring tool's tip touches the workpiece surface at the intermediate point of the edge, the tool can escape obliquely upward from the workpiece surface, preventing an excessive force from being generated. (Fig. 3.1.4.4(c))

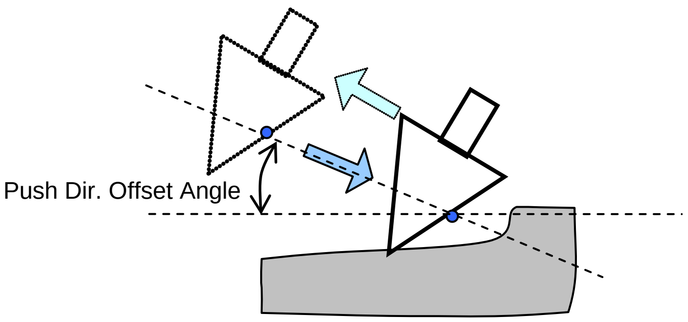


Fig. 3.1.4.4(c) When the tool's pushing direction offset angle is greater than 0 deg

- When "Fixed tool spin, keep normal" is selected, the angle formed by the pushing direction of the tool and the machined surface is 0 degrees and cannot be changed.

3.1.5 Adding a Vision Sensor

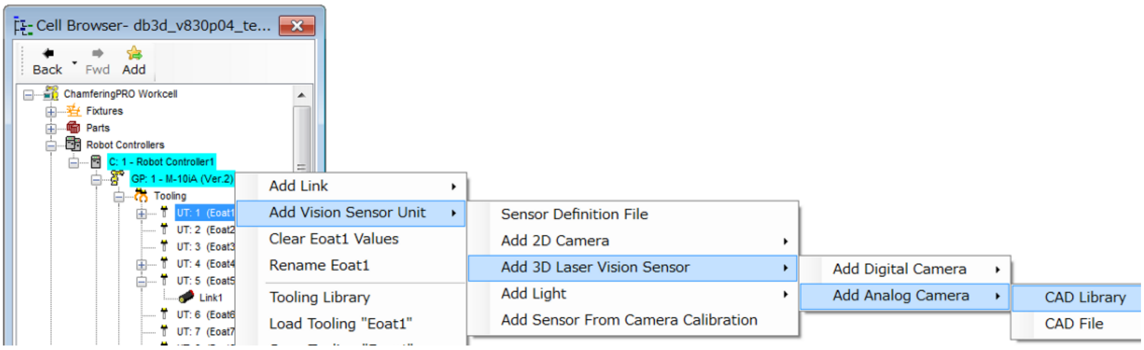
There are two methods for adding a vision sensor (3D Laser Vision Sensor or camera).

1 Manually add and place a vision sensor.
2 Use camera calibration data to add and automatically place a vision sensor.

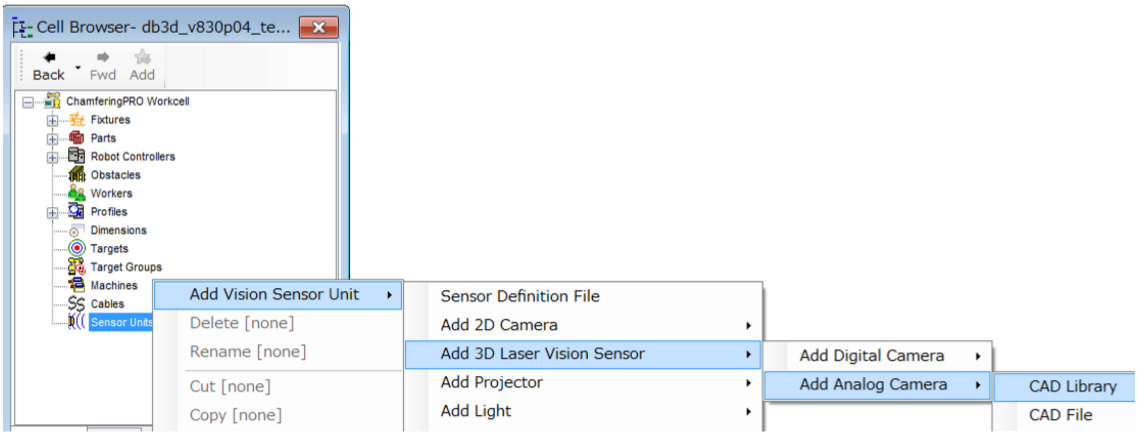
3.1.5.1 Manually adding and placing a vision sensor

Manually add and place a vision sensor (3D Laser Vision Sensor or camera) in the workcell according to the actual deburring system by following the procedures below:

1 On Cell Browser, expand "Tooling" and right-click "UT:5" ("Sensor Units" for a fixed camera). From the displayed right-click menu, select "Add Sensor Unit" → "Add 3D Laser Vision Sensor" or "Add 2D Camera" → "CAD Library" (Fig. 3.1.5.1(a)). On the "Image Librarian" window, select "3DL_UNIT" or another item from "Others" → "Camera" category. (Fig. 3.1.5.1(b))



Adding a robot-mounted camera



Adding a fixed camera

Fig. 3.1.5.1(a) Adding a vision sensor

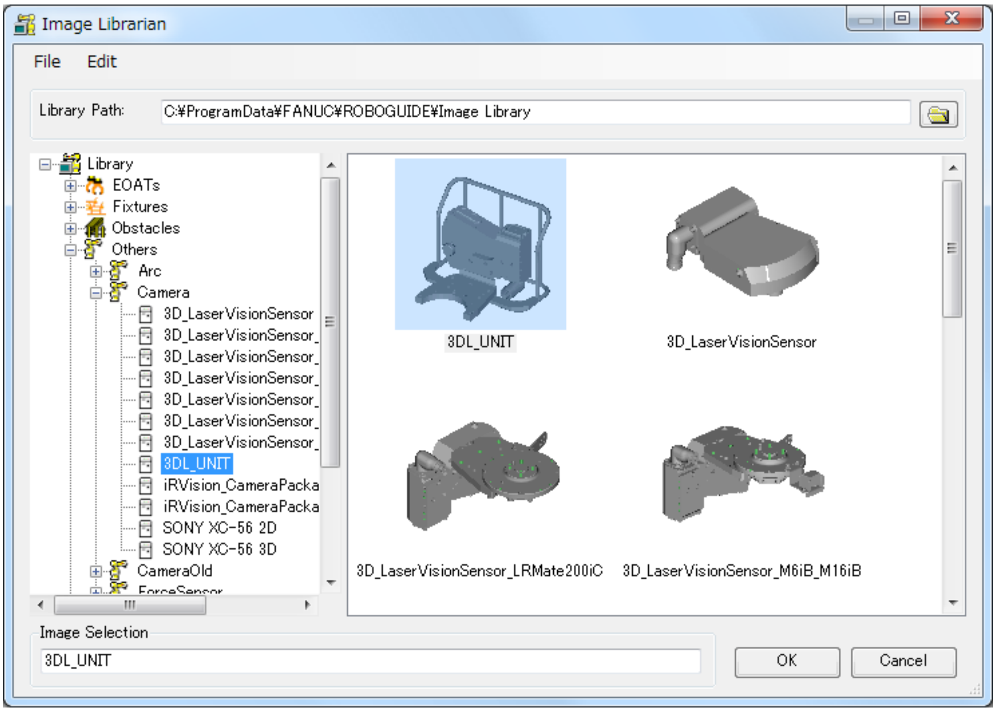
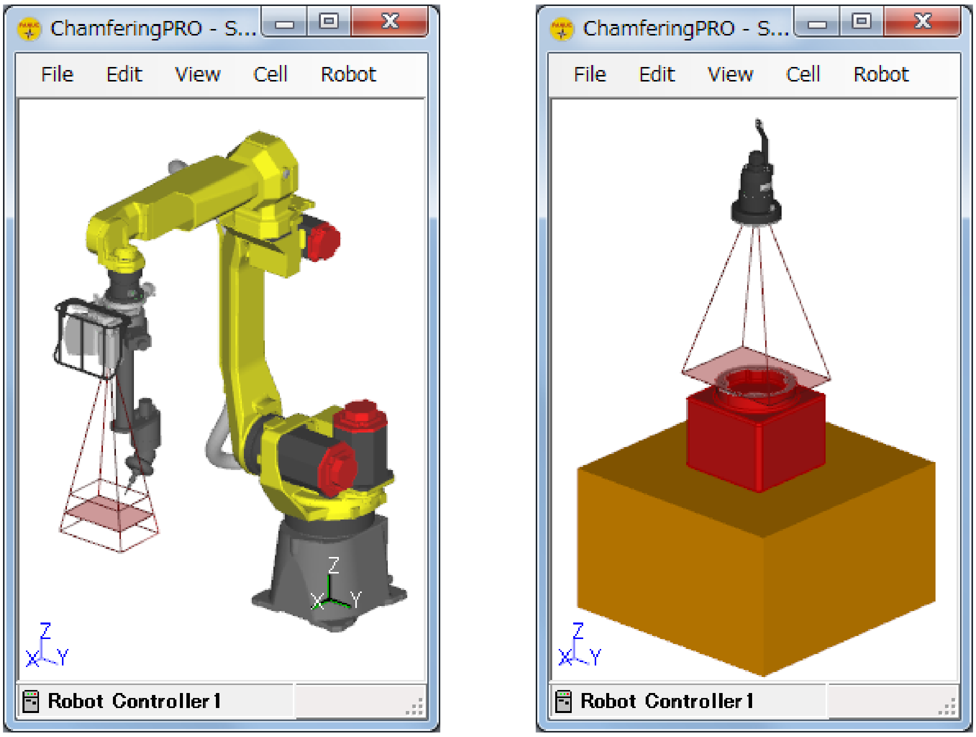


Fig. 3.1.5.1(b) Selecting a vision sensor model

2 On Cell Browser, the vision sensor is added under "Tooling" (SensorUnit1 under "Sensor Units" for a fixed camera) and the property page of the vision sensor is opened. The added vision sensor is displayed as shown in Fig. 3.1.5.1(c).



Robot-mounted camera (3D Laser Vision Sensor) **Fixed camera (camera)**

Fig. 3.1.5.1(c) Added vision sensor

Adjust the position of the vision sensor on the "General" tab of the vision sensor property page. Also set the focus length and standoff of the camera on the "Setting" tab. (Fig. 3.1.5.1(d))

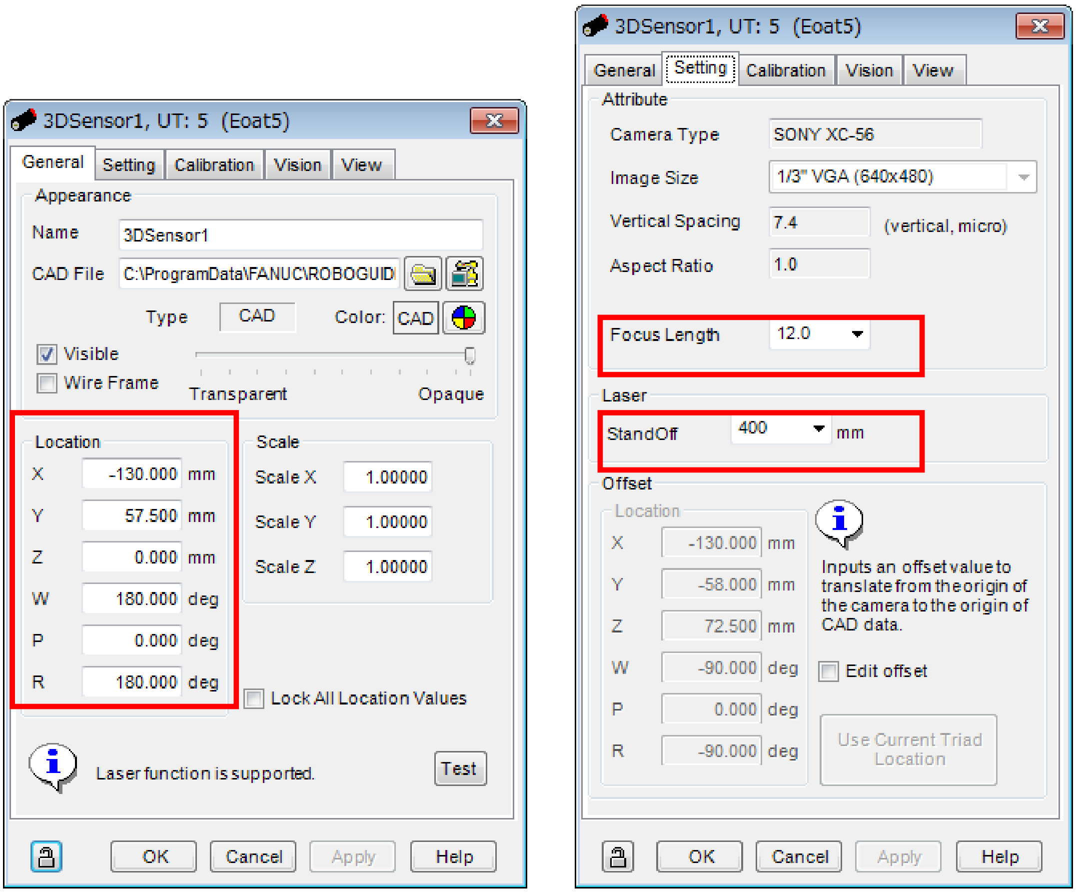


Fig. 3.1.5.1(d) Vision sensor property page

3 On Cell Browser, expand "Robot Controller" and right-click "Vision". From the displayed right-click menu, select "Enable Vision Simulation" (Fig. 3.1.5.1(e)) and restart the robot controller.

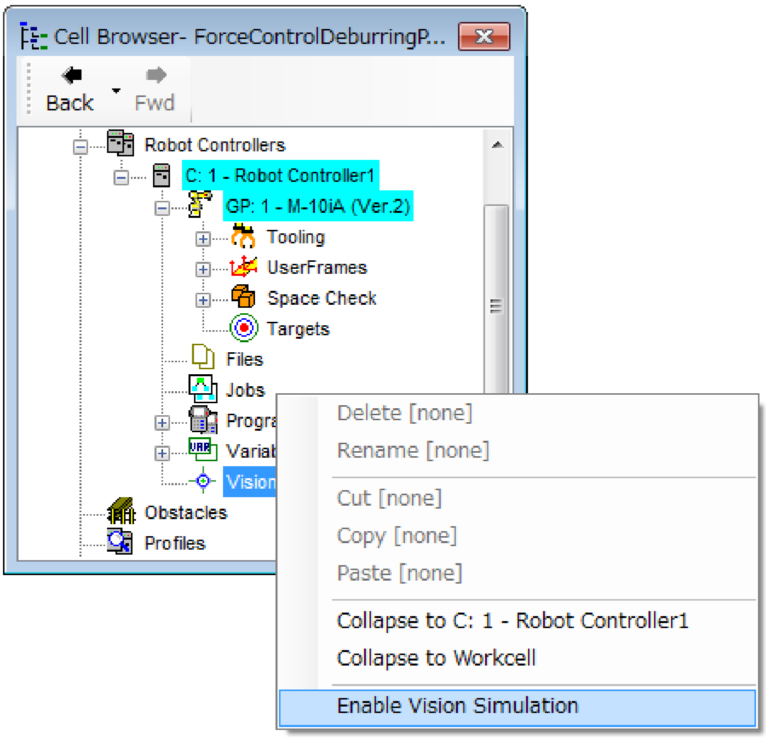


Fig. 3.1.5.1(e) Enable Vision Simulation

4 Open the Vision property page and assign the camera to a port in "Relation of Camera" on the "General" tab of the Vision property page. (Fig. 3.1.5.1(f))

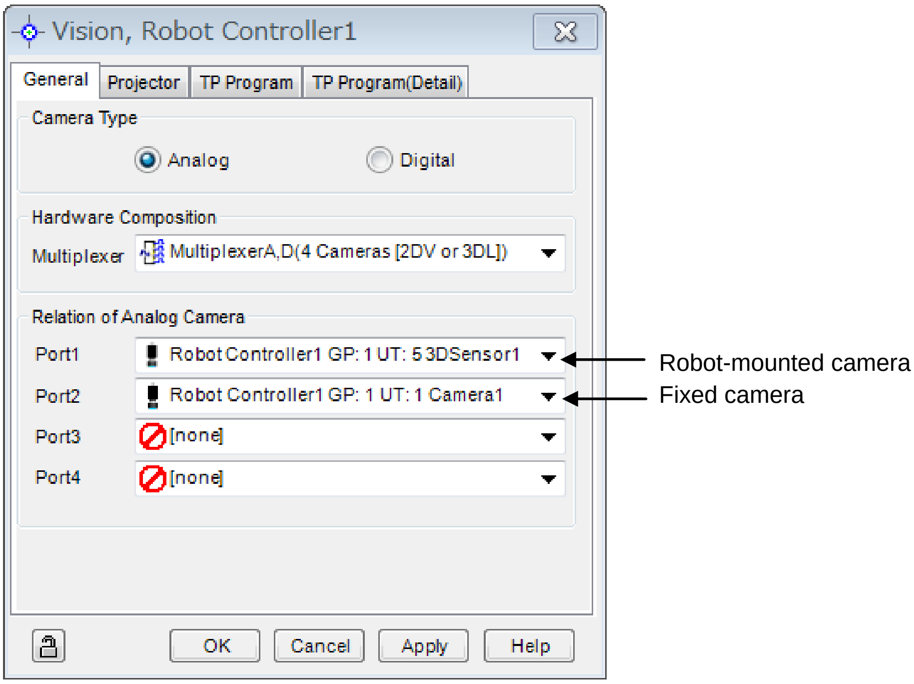


Fig. 3.1.5.1(f) Relation of Camera

3.1.5.2 Using camera calibration data to add and automatically place a vision sensor

By importing camera calibration data of a vision sensor (3D Laser Vision Sensor or camera) of an actual robot, you can add the vision sensor to the workcell, and automatically place it. While a vision sensor is placed first and camera calibration data is created in the normal method, already existing camera calibration data is used to create and place a new vision sensor in this method. In this method, it is not necessary to perform vision sensor placement operation described in Subsection 3.1.5.1, "Manually adding and placing a vision sensor".

1 Select "Enable Vision Simulation". For details, see step 3 in Subsection 3.1.5.1, "Manually adding and placing a vision sensor".
2 Import camera calibration data of a vision sensor (3D Laser Vision Sensor or camera) of an actual robot into the virtual robot simulator.
3 On Cell Browser, right-click "Tooling" → "UT: 1" ("Sensor Units" for a fixed camera). From the displayed right-click menu, select "Add Vision Sensor Unit" → "Add Sensor From Camera Calibration". (Fig. 3.1.5.2(a))

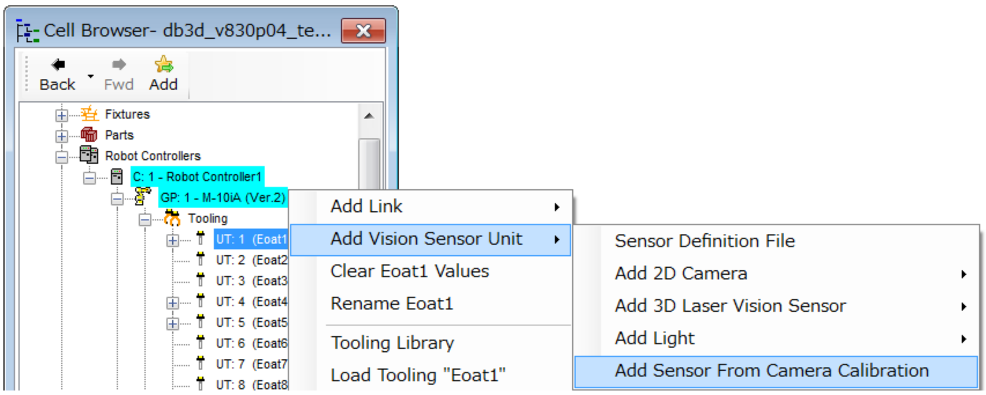


Fig. 3.1.5.2(a) Adding a vision sensor from camera calibration data

4 On the Select Camera Calibration window (Fig. 3.1.5.2(b)), select camera calibration data loaded on the robot controller and click the OK button.

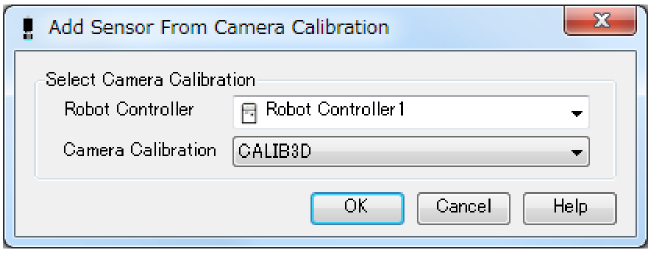


Fig. 3.1.5.2(b) Select Camera Calibration window

5 The vision sensor position is automatically calculated by using the camera calibration data. A new vision sensor is created and mounted on the tool ("SensorUnit1" of sensor unit for a fixed camera). (Fig. 3.1.5.2(c))

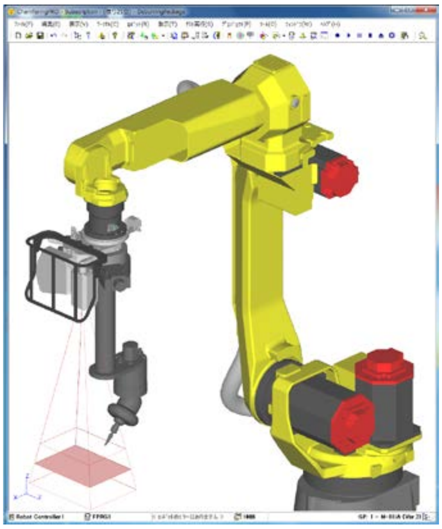


Fig. 3.1.5.2(c) Automatic placement of a vision sensor

> ⚠ **CAUTION**
> When "Enable Vision Simulation" has already been selected, the vision sensor is also assigned automatically to the same port as from camera calibration data. If another vision sensor has already been assigned to the port, however, assign the vision sensor to other port manually. For details, see step 4 in Subsection 3.1.5.1, "Manually adding and placing a vision sensor".

3.1.6 Adding a Fixture

Add a fixture to the workcell according to the following procedures. The fixture is used to put a part (workpiece) on it.

1 Select "Tools" → "Options" from the ROBOGUIDE menu to open the Options window. (Fig. 3.1.6(a)) On the "General" tab of this window, set the "Object Quality" in the "CAD Import" to the "Best Quality". Besides, confirm that the "Overlap Length for Closed Loop" on the "CAD To Path" tab is 0.00 mm.

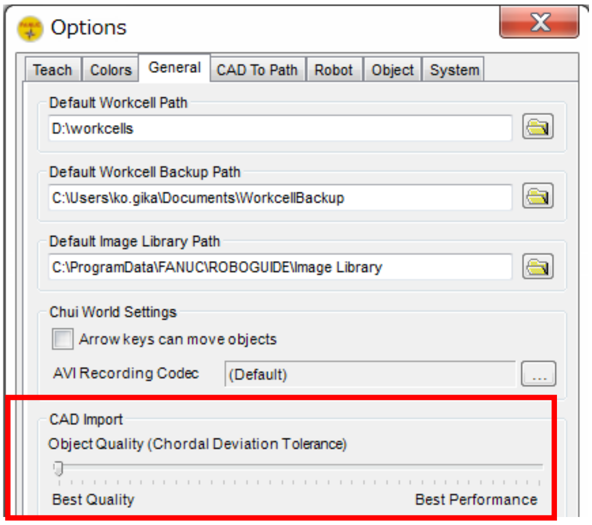


Fig. 3.1.6(a) CAD Import Object Quality

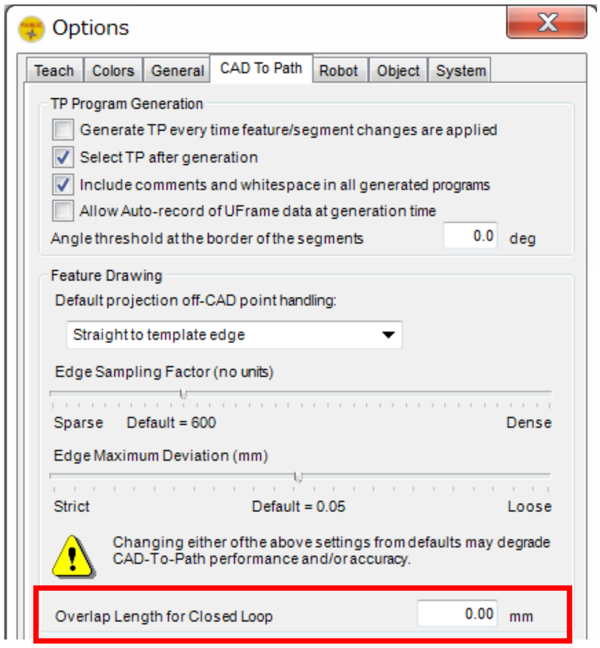


Fig. 3.1.6(b) Overlap Length for Closed Loop

2 On Cell Browser, right-click "Fixtures". From the displayed right-click menu, select "Add Fixture" → "Box" or another item to add a fixture (Fig. 3.1.6(c)).

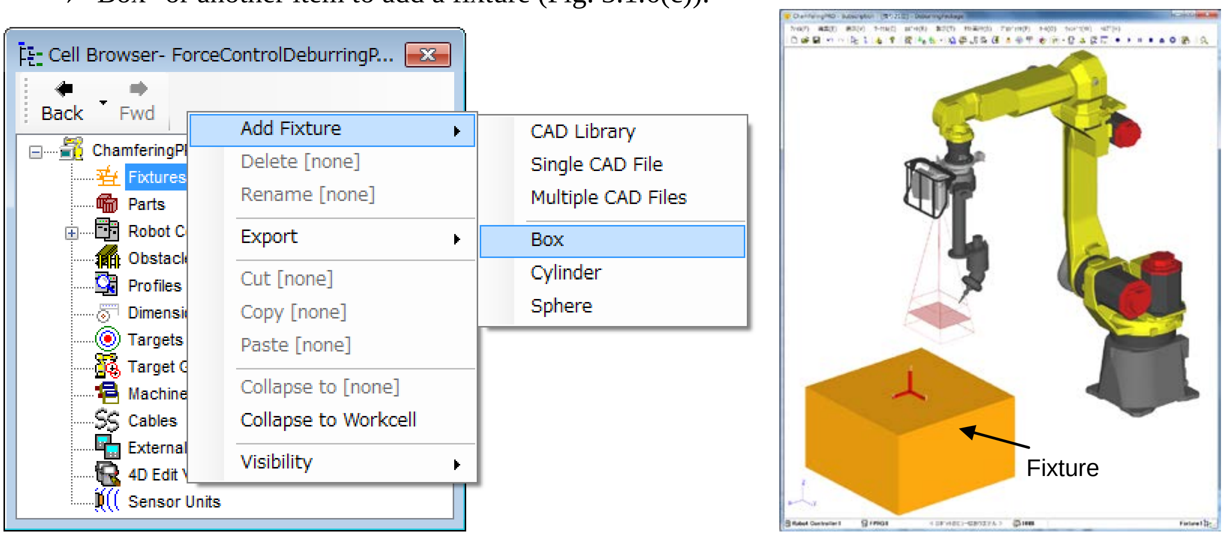


Fig. 3.1.6(c) Adding a fixture

3 Open the property page of the fixture (Fig. 3.1.6(d)). On the "General" tab of the fixture property page, adjust the location and size of the fixture according to the actual deburring system.

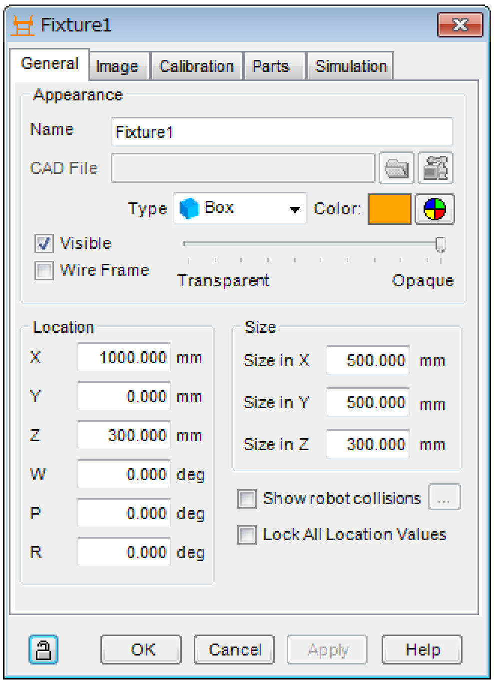


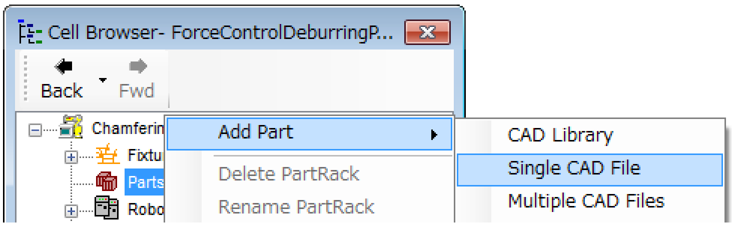
Fig. 3.1.6(d) Adjusting the location and size of the fixture

3.2 ADDING A PART

Add the CAD model of the target workpiece (part) to the workcell and place the model on the fixture according to the following procedures. If you want to place different types of parts in different positions in the workcell, import CAD data of parts as many times as the number of types of parts.

> ⚠ **CAUTION**
> Part copy and paste functions are not supported on Cell Browser for this function.

1 On Cell Browser, right-click "Parts". From the displayed right-click menu, select "Add Part" → "CAD File". On the "Browse for Part 3D Model" window (Fig. 3.2(a)), select the CAD model (IGES format data) of the workpiece to be machined. In the following description in this manual, a part named "T201" is used as an example.



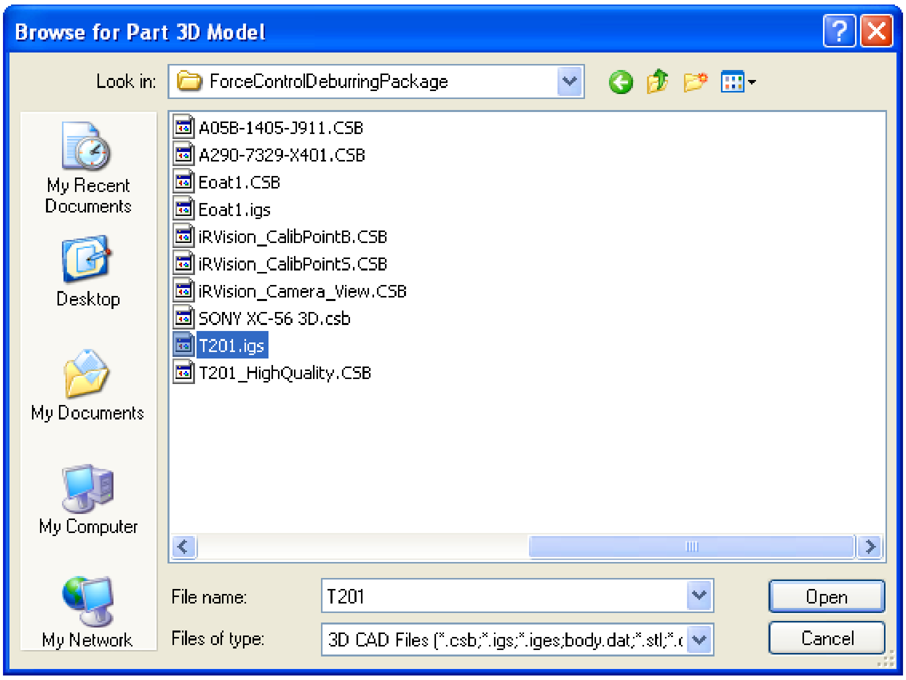


Fig. 3.2(a) Adding a part

> ⚠ **CAUTION**
> ROBOGUIDE allows you to input CAD data (IGES format data). The method for outputting IGES data differs in different CAD software products. Check the IGES output setting of your CAD software product and select the output options of general surface and trimmed surfaces. (IGES solid data is not supported).

2 The Quality Options window appears. Select "High Quality". (Fig. 3.2(b))

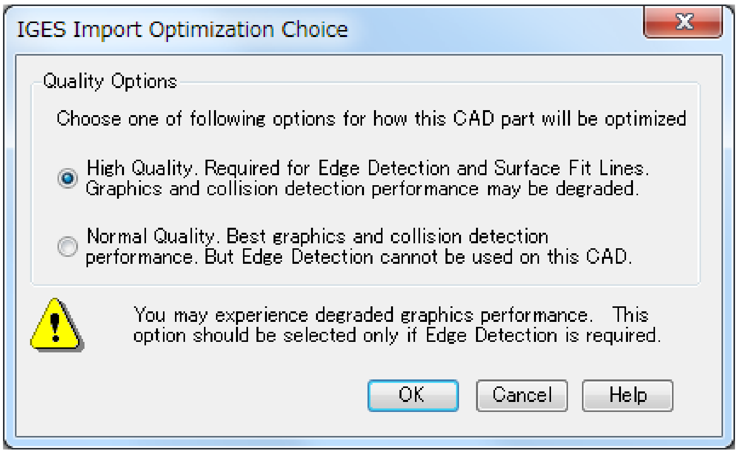


Fig. 3.2(b) Quality Options

3 Open the fixture property page (Fig. 3.2(c)), select the added part (T201) on the "Parts" tab of the fixture property page, and click the "Apply" button to assign the part to the fixture. Check "Edit Part Offset" and adjust the position of the part.

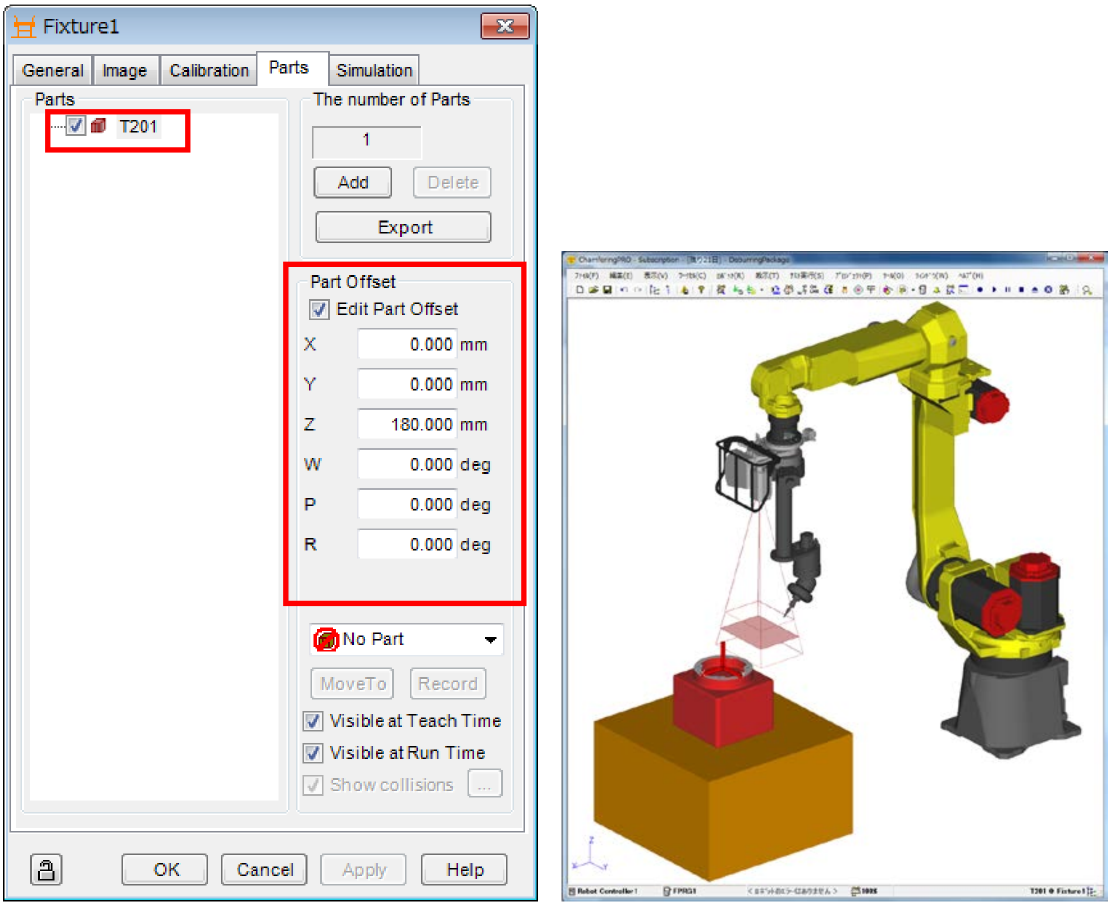


Fig. 3.2(c) "Parts" tab of the fixture property page

> ⚠ **CAUTION**
> Set a part name by following the rules below:
> - A part name can consist of up to 24 characters.
> - The configuration rule of a TP program name also applies to a part name. That is, only alphanumeric characters, underscores, and one-byte katakana characters can be used for a part name. Any part name cannot begin with a numeric character.

3.3 SELECTING AN EDGE

Select a target edge for deburring by using CAD to Path Quickbar according to the following procedures. If you want to select multiple edges on the workpiece, repeat the following steps. Perform steps 2 and 3 when required, however.

1 Draw a target edge for deburring.
2 Adjust the orientation of the deburring tool.
3 Set edge parameters.

3.3.1 Drawing an Edge

Draw a target edge (feature) for deburring according to the following procedures:

1 Click the "Draw features on parts" button  on the toolbar to display CAD to Path Quickbar. (Fig. 3.3.1(a))
2 On Cell Browser, click a tool frame that has a deburring tool to select it.
3 Click a part to select it.

4 If you want to draw a closed edge, click the "Closed Loop" button on CAD to Path Quickbar. If you want to draw an open edge, click the "Edge Line" button on CAD to Path Quickbar.

5 Click points on a target edge for deburring of a part sequentially from the start point so that the tool moves left in the pushing direction. Double-click the end point. A feature is defined on the edge.
When a closed edge is drawn, the start and end points are defined in the same position. When an open edge is drawn, the last clicked point is defined as the end point of the edge.

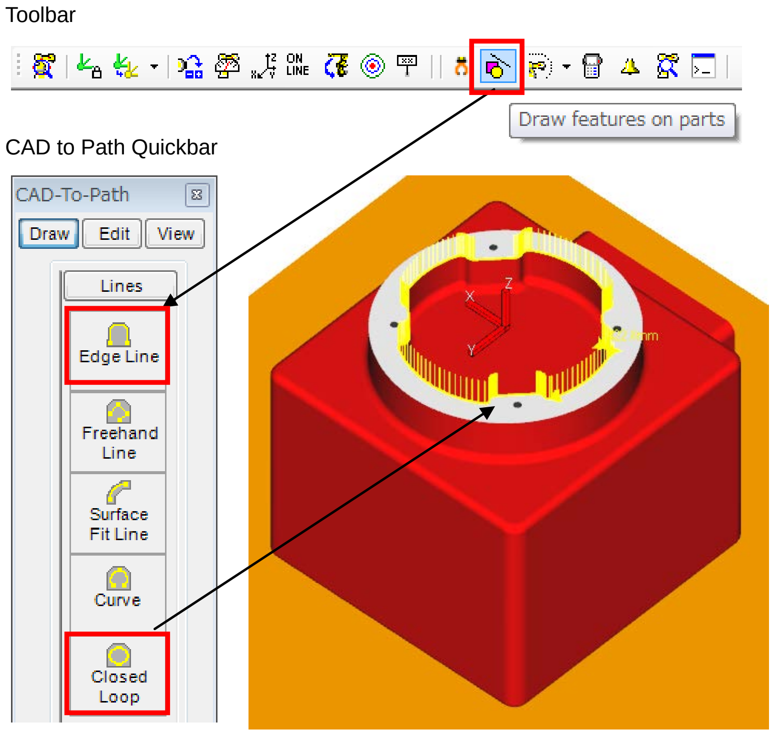


Fig. 3.3.1(a) Drawing an edge

6 On Cell Browser, a feature (edge) is automatically added under the part (Fig. 3.3.1(b)). Open the property page of the feature.
On the feature property page, you can set the orientation of the deburring tool and edge parameters.

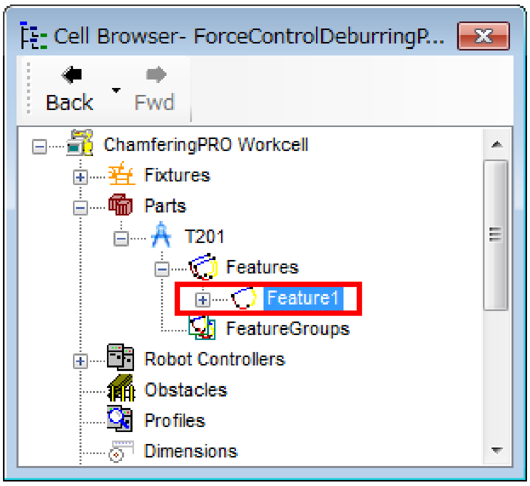


Fig. 3.3.1(b) Added edge

⚠ **CAUTION**

1 Set an edge name by following the rules below:
- An edge name can consist of up to 32 characters.
- The configuration rule of a TP program name also applies to an edge name. That is, only alphanumeric characters, underscores, and one-byte katakana characters can be used for an edge name. Any edge name cannot begin with a numeric character.

2 If points are clicked so that the tool moves right in the pushing direction or multiple edges are drawn, delete the feature from Cell Browser and draw the edge once again.

3 When teaching the start point of an edge, do not click any corner of the edge.

4 When teaching the start point of an edge, consider the range of each axis of the robot.

3.3.1.1 User frame set for each edge

A user frame is set for each edge as shown below. (Fig. 3.3.1.1)

- The user frame having the number set on the "DeburrPathAutoGen" tab of the part property page is used. The origin of the user frame coincides with the start point of the edge. The XY plane coincides with the machined surface. The +Y axis in the user frame coincides with the direction of the edge at the start point. The +Z axis in the user frame is located in the direction away from the machining plane.
- To the edge data file, the offset from the base position of the workpiece to the start point of each edge (user frame) is output. For the base position, see "Setting of the base position of the workpiece" in Section 3.4, "SETTING TARGETS".
- In the case of an actual workpiece, the user frame at the edge is calculated by using the base position of the actual workpiece and the offset of the edge.

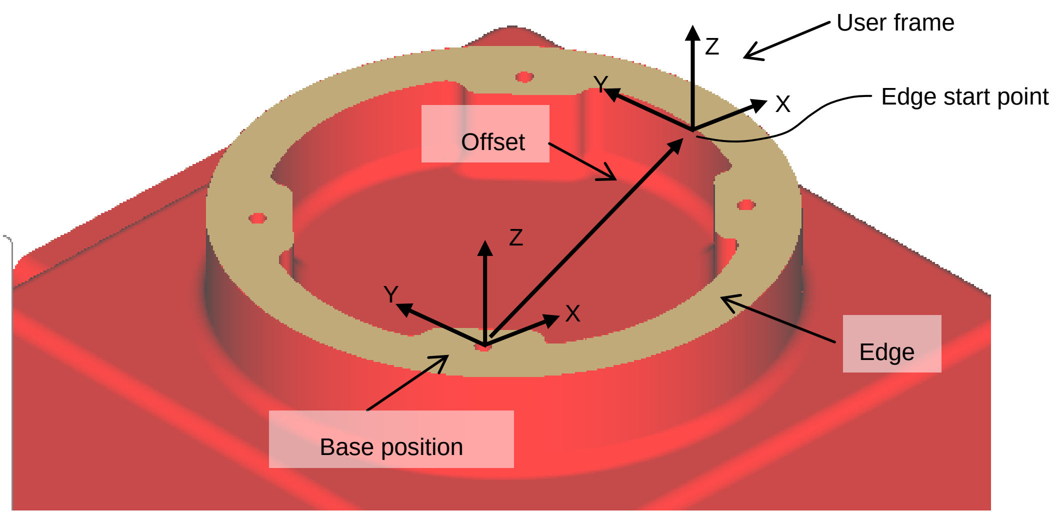


Fig. 3.3.1.1 Relationship between the base position of the workpiece and the user frame of the edge

3.3.2 Adjusting the Orientation of the Deburring Tool

Adjust the orientation of the deburring tool to the edge as required.

⚠ **CAUTION**

1 The feature TP program (FPRG01.TP) that is generated by clicking "Generate Feature TP Program" in the "General" tab of the feature property page (Fig. 3.3.2) is different from the deburring path program generated in this package.

2 To check on the generated deburring path, see Appendix B, "SIMULATING DEBURRING OPERATIONS WITH ROBOGUIDE".

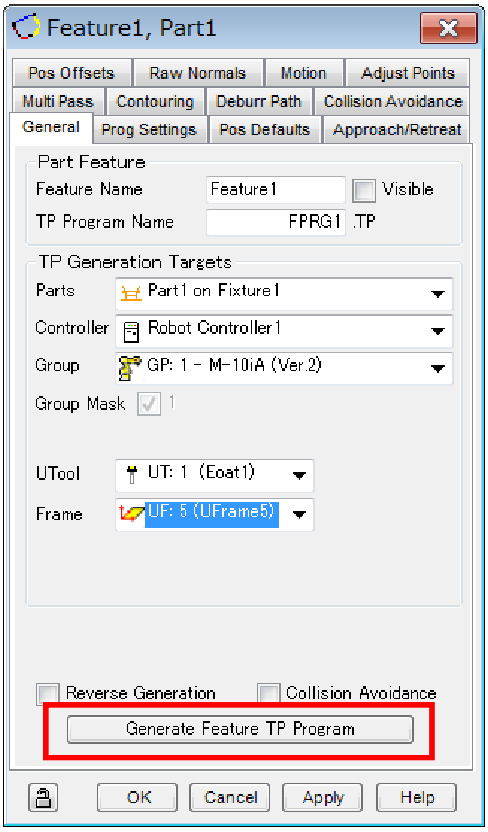


Fig. 3.3.2 Generate Feature TP Program

3.3.2.1 Adjusting the orientation of the deburring tool to the entire edge

You can adjust the orientation of the deburring tool to the entire edge according to the following procedures:

1 On the "Pos Defaults" tab of the feature property page, enable "Show the Tool Preview" to display the tool preview. (Fig. 3.3.2.1(a))

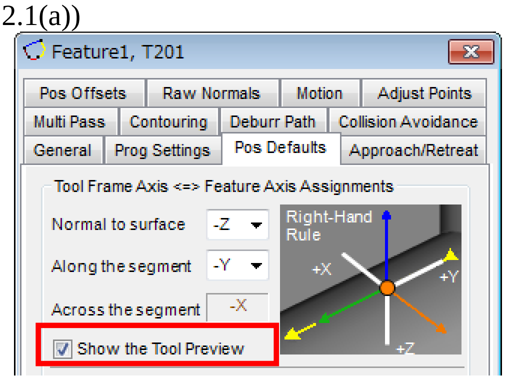


Fig. 3.3.2.1(a) Enabling "Show the Tool Preview"

2 On the "Raw Normals" tab of the feature property page, enable "Override and Blend raw normals" and click the "Apply" button. Enter an inclination angle in "Rotate:Along the segment" and "Rotate:Across the segment" under "Start Normal Offset" and "End Normal Offset" and check the orientation of the tool. (Fig. 3.3.2.1(b))

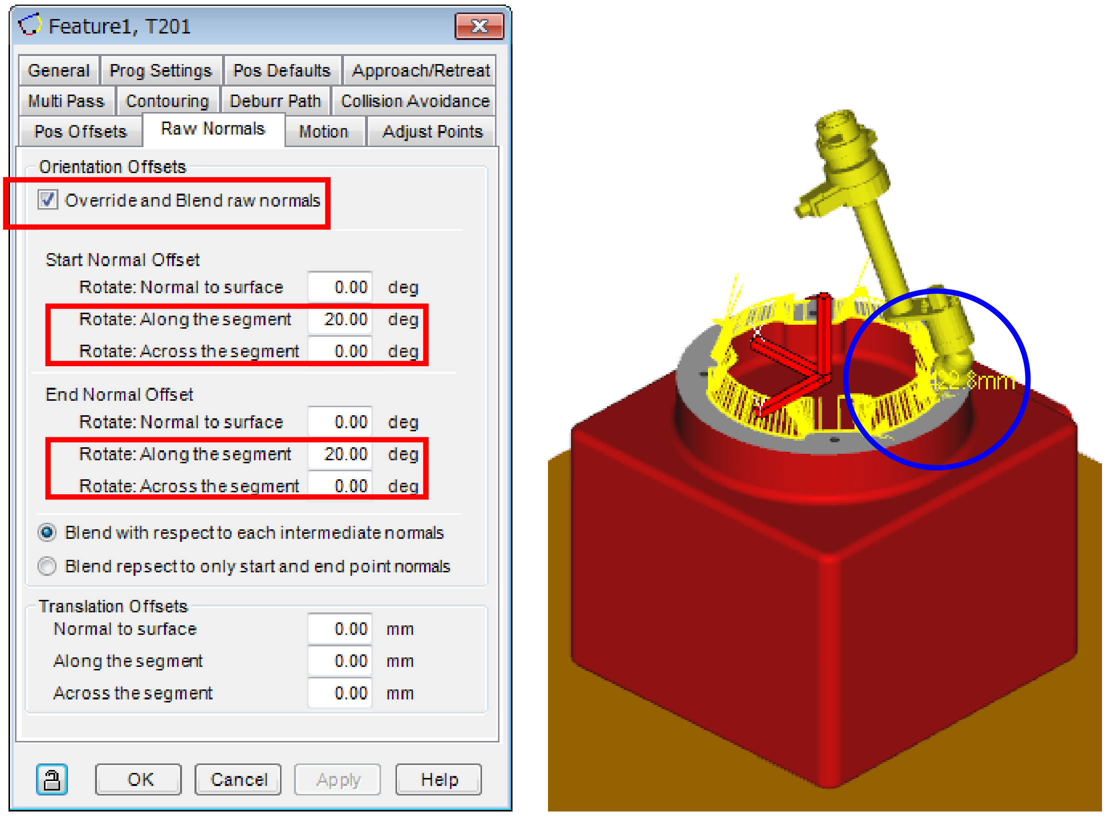


Fig. 3.3.2.1(b) Setting normal offset angles

⚠ **CAUTION**

When the edge is closed, the same rotation angles must be set for the start and end normal offset points of the edge.

TIPS

You can change the feature display mode by clicking the "View" button on CAD to Path Quickbar. "Show Tooling CAD" allows you to display the tool preview. "Scale Tooling CAD" allows you to change the size of the preview. (Fig. 3.3.2.1(c))

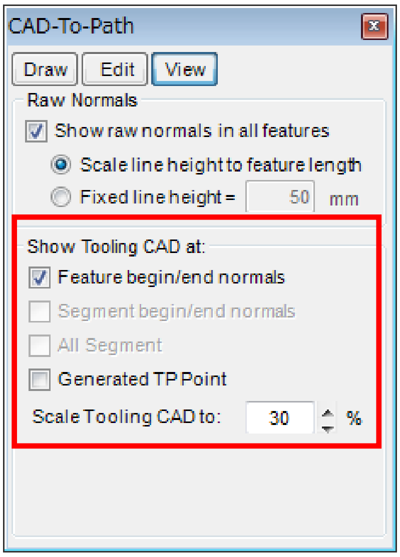


Fig. 3.3.2.1(c) Displaying the tool preview

3.3.2.2 Adjusting the orientation of the deburring tool in different positions

You can adjust the orientation of the deburring tool in different positions according to the following procedures:

1. Right-click, for example, "Segment1" under a feature on Cell Browser. From the displayed right-click menu, select "Split Segment1" to split the segment. If you want to adjust the orientation of the deburring tool in different positions, split the feature into multiple segments in advance.
2. Double-click a segment in which to adjust the orientation of the tool to open the property page of the segment. On the "Pos Defaults" tab of the segment property page, enable "Show the Tool Preview" to display the tool preview.
3. On the "Raw Normals" tab of the segment property page, enable "Override and Blend raw normals" and click the "Apply" button. Enter an inclination angle in "Rotate:Along the segment" and "Rotate:Across the segment" under "Start Normal Offset" or "End Normal Offset" and click the "Apply" button. You can check the orientation of the tool. (Fig. 3.3.2.2)

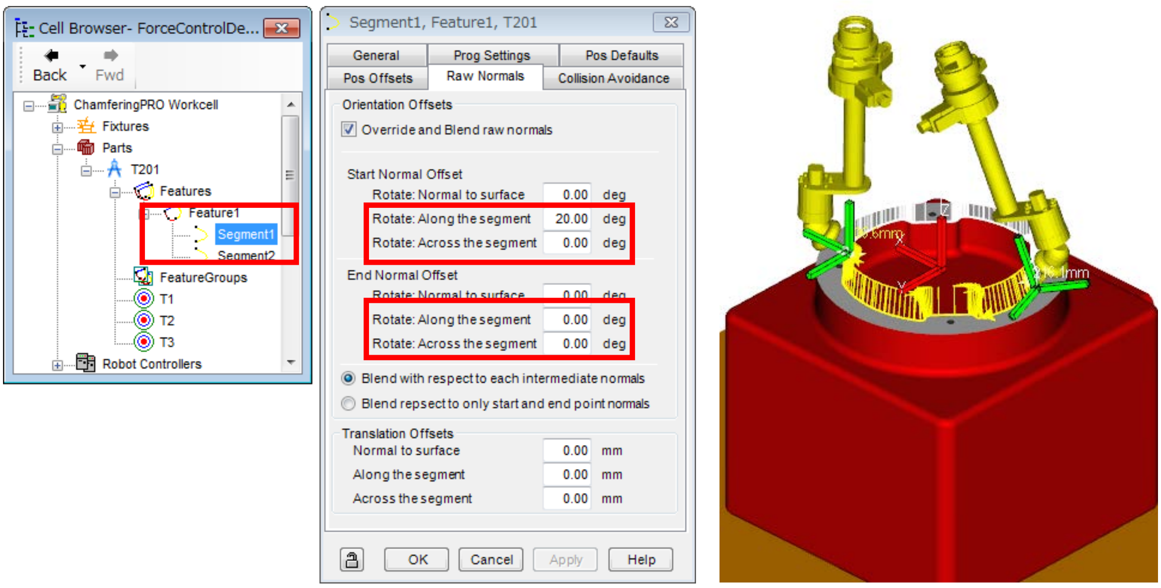


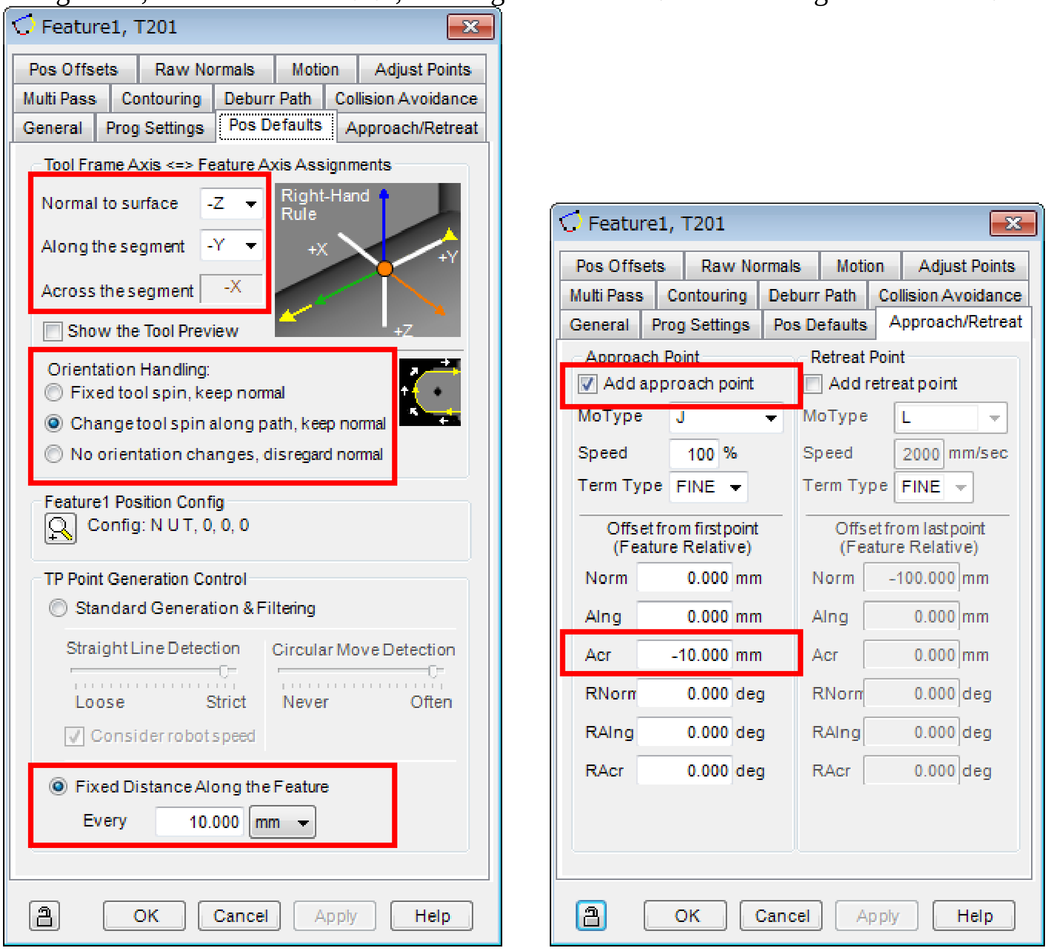
Fig. 3.3.2.2 Setting normal offset

> ⚠ **CAUTION**
> 1 When the edge is closed, the same rotation angles must be set for the start and end normal offset points of the edge.
> 2 The same tool orientation must be set at the end point at which two continuous segments touch each other. (Tool orientation may differ even when the rotation angles are the same.)

3.3.3 Setting Edge Parameters

To set different parameters for different edges, set the parameters for each edge on the "Pos Defaults", "Approach/Retreat", "Deburr Path", and "Contouring" tabs of the property page of the edge (feature). (Fig. 3.3.3)

For the setting items, see Subsection 3.1.4, "Setting the Default Values for Edge Parameters".



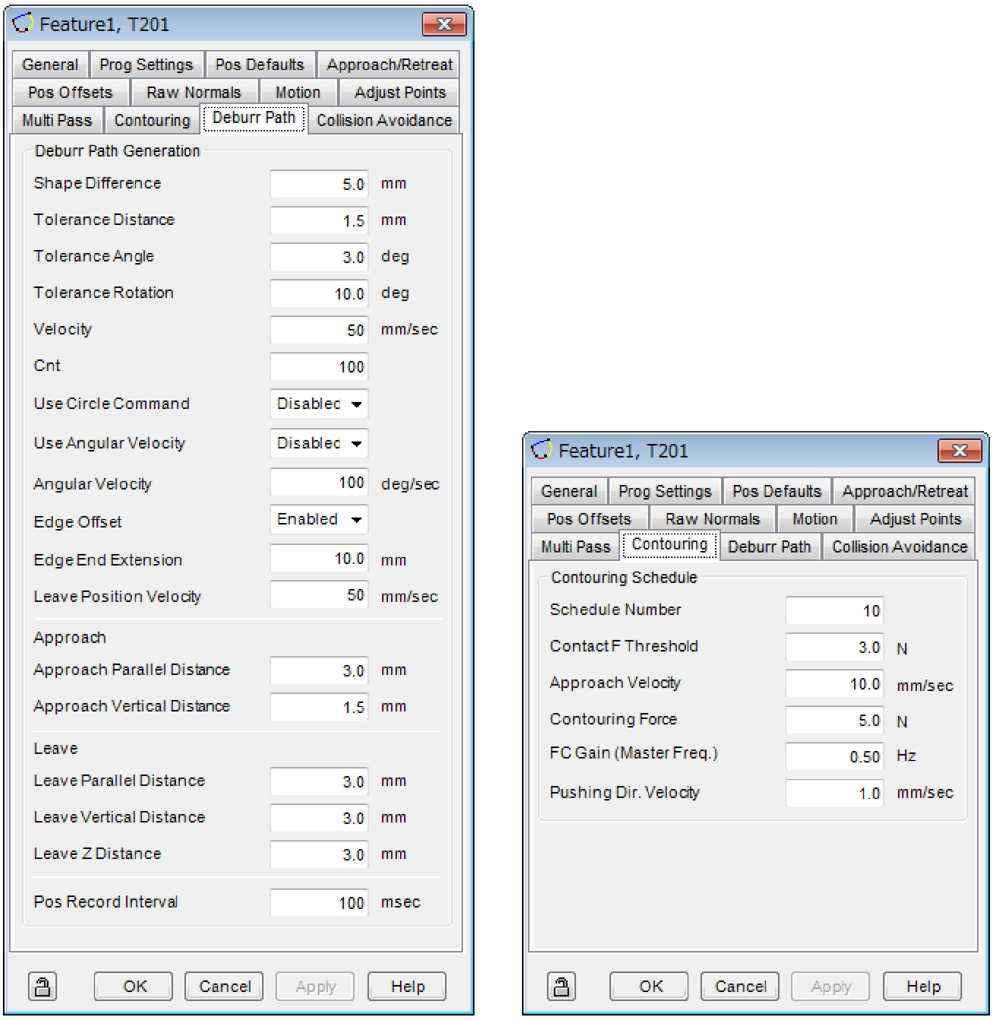


Fig. 3.3.3 Setting Edge Parameters

⚠ **CAUTION**
If you want to deburr multiple edges on the workpiece, define and set the feature in the CAD model as described above for each edge respectively.

3.4 SETTING TARGETS

Set three targets to be used for calculating the base position of the workpiece by using the target tool according to the following procedures:

1 Click the "Show/Hide Target Tools" button on the toolbar to display the target tool. (Fig. 3.4(a))
2 Click a part to select it.
3 Click the "Surface" button on the target tool to select it. (Fig. 3.4(a))
4 While holding down the Alt+Shift key, click an item such as a machined hole on the machined surface of the part to place a target at the center of the hole. (Fig. 3.4(a))

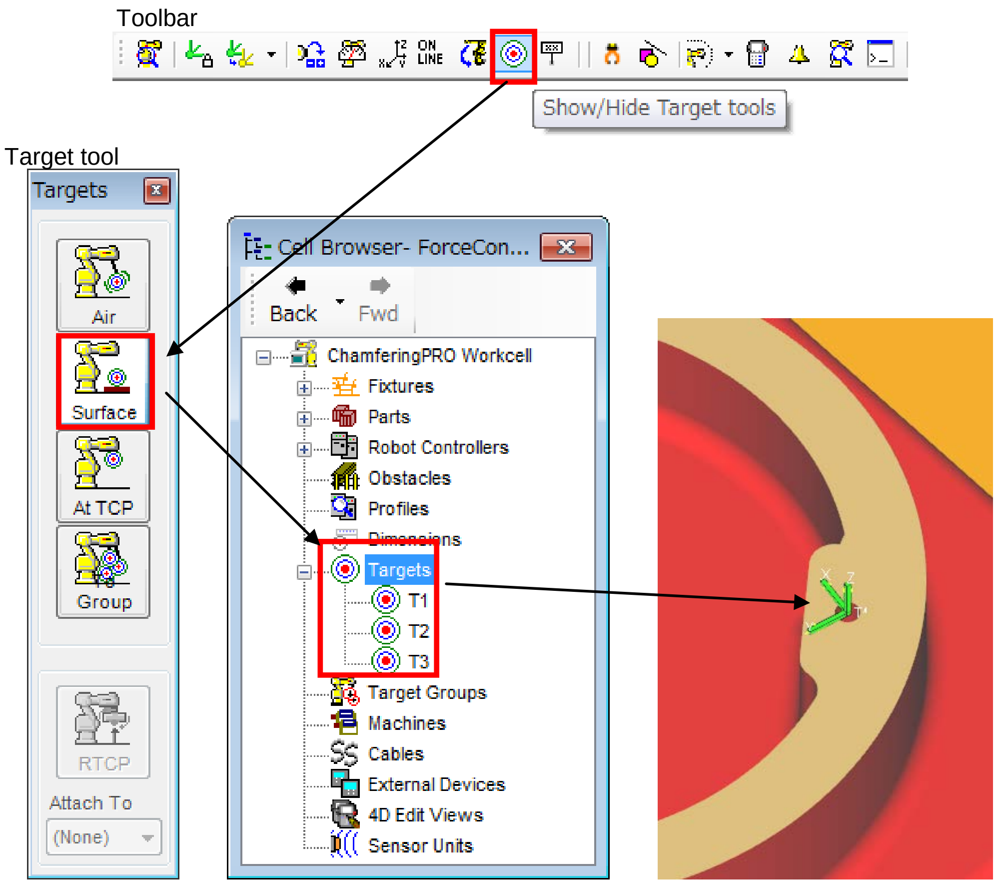


Fig. 3.4(a) Placing a target

5 Open the property page of the target (Fig. 3.4(b)), select part "T201 on Fixture1" for "Attached" on the "General" tab of the target property page, and click the "Apply" button. The target moves under part T201. As shown in Fig. 3.4(c), set the target so that +Z direction is normal to the machined surface and away from the machined surface.

6 Repeat steps 2 to 5 above to set three targets at positions as far away from one another as possible on the workpiece. (Fig. 3.4(c)) The distance between any two targets must be at least 15 mm.

TIPS

In the generated TP program, the orientation of the robot-mounted camera coincides with the orientation of the target. When the orientation of the target (around Z) changes, the orientation of the camera at the detection position also changes.

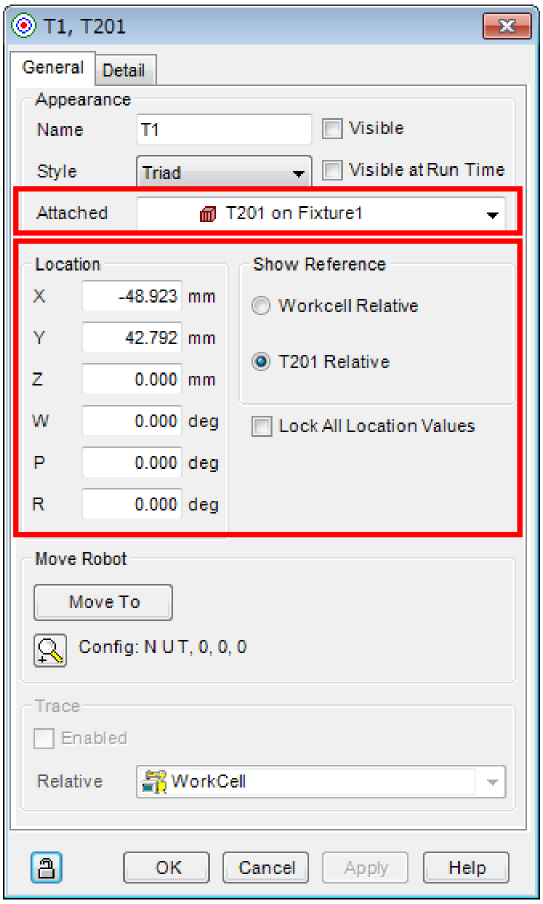


Fig. 3.4(b) Target attached to a part

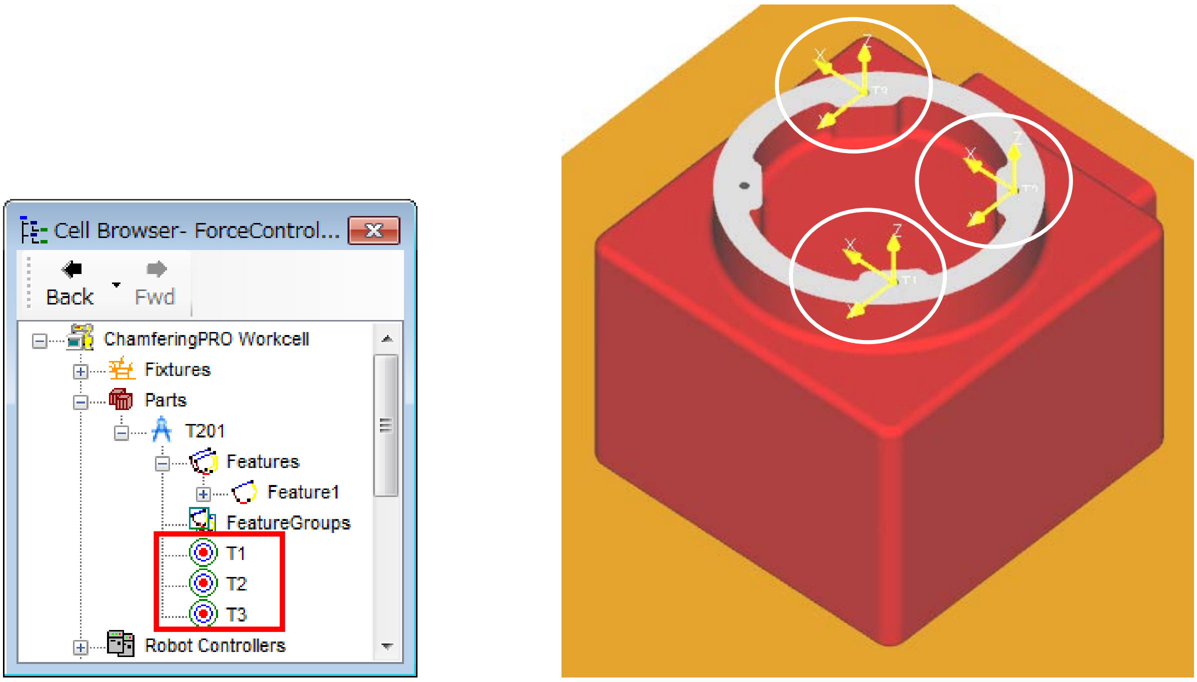


Fig. 3.4(c) Setting targets

Setting of the base position of the workpiece

The base position of the workpiece is set as follows. (Fig. 3.4(d))

1 In ROBOGUIDE, the centers of three machined holes on a part are specified as targets. The base position of the part model is determined based on the positions of the centers of the machined holes.

2 For the actual robot, vision processes for detecting the centers of the machined holes on the actual workpiece are taught, the positions of the centers of the machined holes are detected, and the base position of the actual workpiece is automatically calculated.

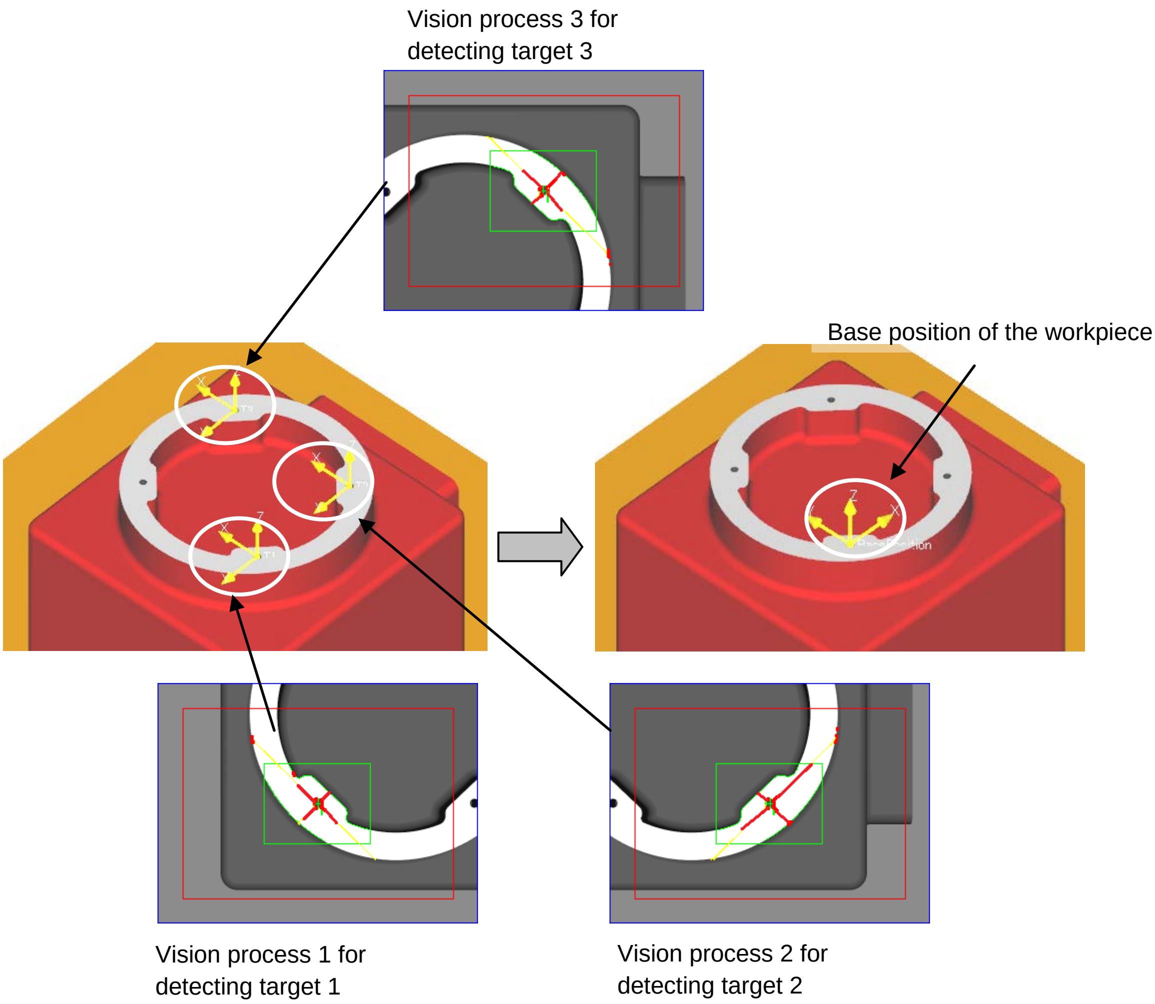


Fig. 3.4(d) Setting of the base position of the workpiece

3.5 GENERATING DATA FILES AND TRANSFERRING THEM TO THE ONLINE ROBOT CONTROLLER

Set Deburring Path Auto Generation and generate data files. Export the generated files to a medium such as a USB memory and transfer them to the controller.

> ⚠ **CAUTION**
> This function uses the following registers, user frame, and other items by default. Change the values on the "DeburrPathAutoGen" tab of the part property page when required.
> - UFrame UF[5], UTool UT[5], and Vision Register VR[5] → For details, see Subsection 3.5.1, "Setting Deburring Path Auto Generation".
> - Register R[51], and User Alarm UALM[5] → For details, see Subsection 3.5.1.2, " Setting edge detection-related items ".

3.5.1 Setting Deburring Path Auto Generation

On the part property page, set the settings of Deburring Path Auto Generation. These settings are reflected to the generated data files.

On Cell Browser, right-click a part. From the displayed right-click menu, select "Property" to open the property page of the part. On the "DeburrPathAutoGen" tab of the part property page, set the following items. (Fig. 3.5.1)

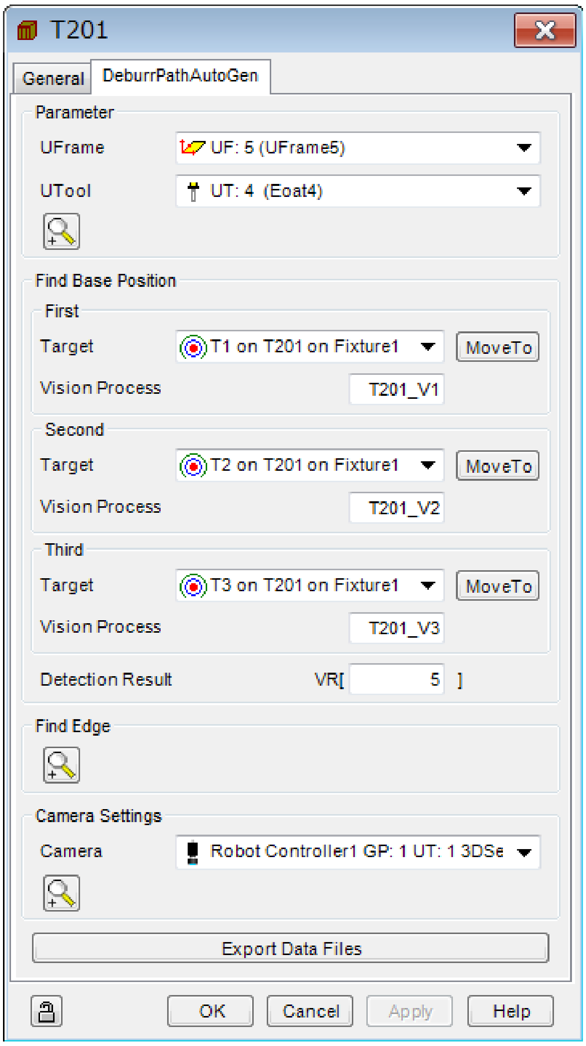


Fig. 3.5.1 "DeburrPathAutoGen" tab

UFrame

Set the number of the user frame set for the machined surface containing the edge.
Default value: 5

UTool

Set the number of the tool frame set for the deburring tool.
Default value: 5

Target

Set three targets used for measuring the base position of the workpiece.
Default value: None

Vision Process

Set the name of an *i*RVision vision process for detecting each of three targets.
If this vision process already exists when data files are generated, the existing vision process is output. If this vision process does not exist, it is newly generated and output. Also, if the camera specified on this screen is already calibrated, the calibration data name is automatically selected in the generated vision process.
Default value: {Part Name}_V1 to {Part Name}_V3

Detection Result

Set a vision register (VR) for storing the detection result of the three targets.
Default value: 5

TIPS

Click the button and set the following items as required:

- Tool-related items
- Edge detection-related items
- Camera-related items

3.5.1.1 Setting tool-related items

Set items related to the deburring tool as required. (Fig. 3.5.1.1(a))

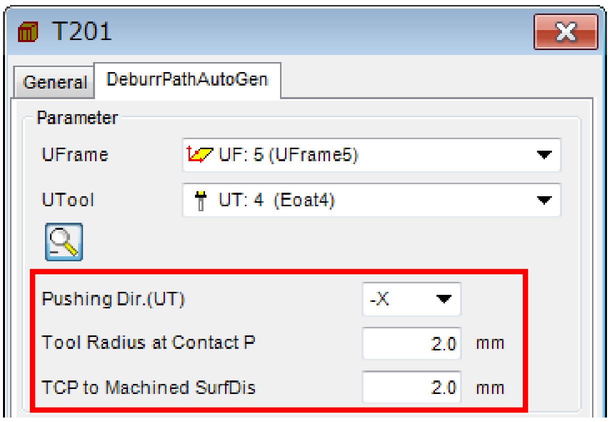


Fig. 3.5.1.1(a) Setting tool-related items

Pushing Dir.

- When "Change tool spin along path, keep normal" is selected, set the tool pushing direction in the tool frame at the edge start point for "Pushing Dir.".
- When "Fixed tool spin, keep normal" is selected, the pushing direction is automatically set, so this setting is not required.

For details of the tool spin axis, see Subsection 3.1.4.1 "Setting position defaults".
Default value: -X

Tool Radius at Contact P

- When "Fixed tool spin, keep normal" is selected, set the tool radius on the machined surface. (Fig. 3.5.1.1(b))
- When "Change tool spin along path, keep normal" is selected, set the distance between the contact point of the tool and workpiece on the machined surface and the tool rotation axis. (Fig. 3.5.1.1(b))

Default value: 2.0 mm

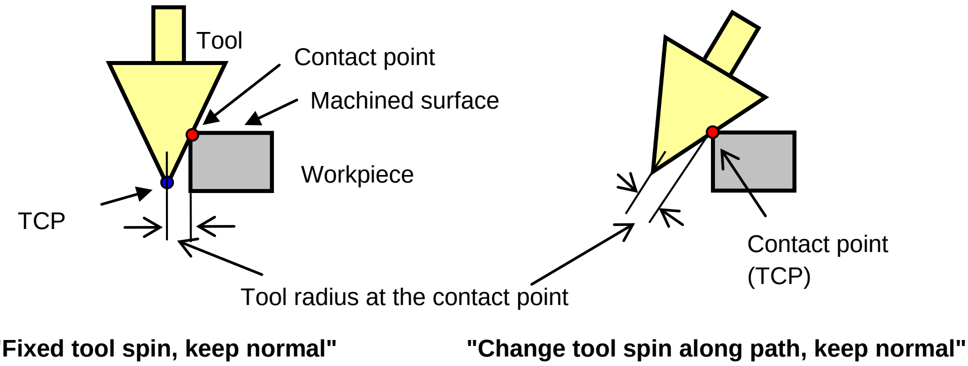


Fig. 3.5.1.1(b) Tool radius at the contact point

TCP to Machined Surf Dis

- When "Fixed tool spin, keep normal" is selected, set the distance between the contact of the tool and workpiece edge and the TCP. (Distance in the Z direction in the user frame set on the machined surface containing the edge) (Fig. 3.5.1.1(c))
- When "Change tool spin along path, keep normal" is selected, you do not need to set this value. (Fig. 3.5.1.1(c))

Default value: 2.0 mm

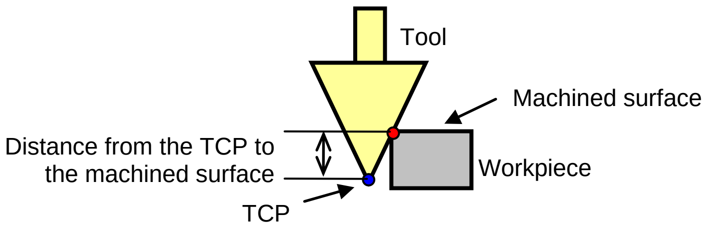


Fig. 3.5.1.1(c) Distance from the TCP to the machined surface

3.5.1.2 Setting edge detection-related items

Set items related to edge detection. (Fig. 3.5.1.2)

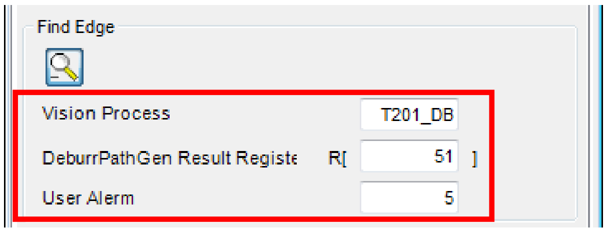


Fig. 3.5.1.2 Setting edge detection-related items

Vision Process

Set the *i*RVision Deburring Line Output Vision Process name.
If this vision process already exists when data files are generated, the existing vision process is output. If this vision process does not exist, it is newly generated and output. Also, if the camera specified on this screen is already calibrated, the calibration data name is automatically selected in the generated vision process.
Default value: {Part Name}_DB

DeburrPathGen Result Register

Set the number of the register to which to output the result of Deburring Path Auto Generation.

- When a deburring path is successfully generated, 0 is output to the result register.
- When the generation of a deburring path fails, -1 is output to the result register.

Default value: 51

User Alarm

Set the number of the user alarm used for the edge detection program and others.
Default value: 5

3.5.1.3 Setting camera-related items

Set camera-related items. (Fig. 3.5.1.3(a))

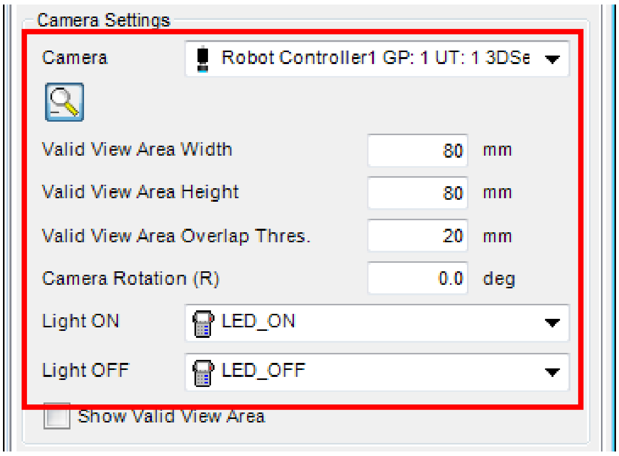


Fig. 3.5.1.3(a) Setting camera-related items

Camera

Select a 3DL Vision Sensor or a camera in the workcell from the list
Default value: None

Valid View Area Width and Height

Set the width and height of the valid view area of the camera. The valid view area of a camera is available for detecting an edge. (For details of the camera view area, refer to Subsection 3.2.2.1, "Sensor head (3D Laser Vision Sensor)" and Subsection 3.2.3.1, "Sensor head (camera)" of "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL B-83434EN".) These values differ depending on how the light is projected to the machined surface and the quality of the machined surface. Check the images of the workpiece taken in the actual system and determine these values.
For a robot-mounted camera, the robot position to take an image is calculated basing on the size of the machined surface containing the edge and the valid view area of the camera as shown below:

- When the size of the machined surface is smaller than the valid view area of the camera, the edge is detected only at one place.
- When the size of the machined surface is larger than the valid view area of the camera, the edge is detected at multiple places.

For a fixed camera, the image is taken only once.
Default value: 80 mm

Valid View Area Overlap Thres.

Define the upper limit of the valid view area overlap dimension (dimension of the valid view area overlapped by two continuous measurements by the *i*RVision Deburring Line Output Vision Process). This value differs depending on how the light is projected to the machined surface and the quality of the machined surface.
Default value: 20 mm

Camera Rotation
Set the camera rotation angle when the edge is detected. (Set this angle when the robot interferes with any peripheral device during the detection of the edge.)
Default value: 0.0 deg

Light ON
Set a TP program called for turning light on at the start of the detection of the edge.
Default value: No Program

Light OFF
Set a TP program called for turning light off at the end of the detection of the edge.
Default value: No Program

Show Valid View Area
The valid view area of the camera is displayed on ROBOGUIDE. (Fig. 3.5.1.3(b))

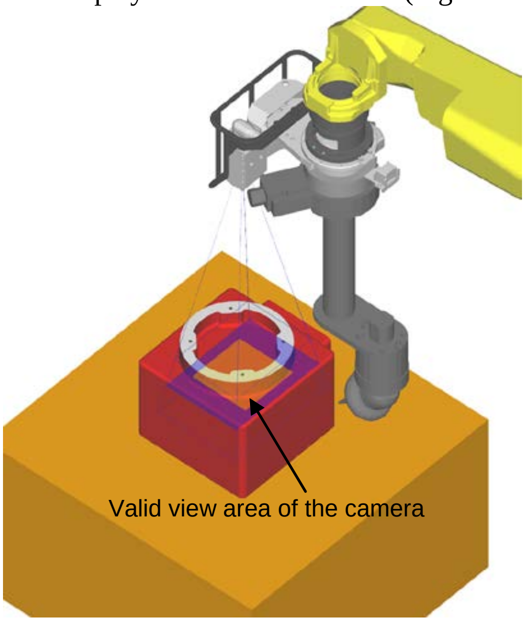


Fig. 3.5.1.3(b) Valid view area of the camera

3.5.2 Exporting Data Files

To reflect the result of offline teaching on ROBOGUIDE to the online robot controller, export data files from ROBOGUIDE and load them onto the online robot controller via a medium such as a USB memory. Click the "Export Data Files" button at the bottom of the "DeburrPathAutoGen" tab of the property page of a part. The "Browser For Folder" window is opened. On this window, specify "USB DISK" or another item for the file export destination. The data files are exported to the specified folder. (Fig. 3.5.2)

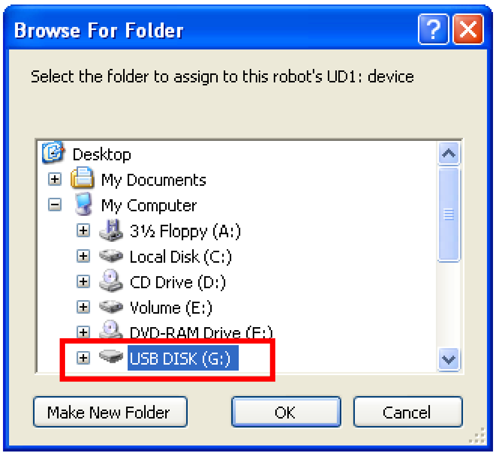


Fig. 3.5.2 Selecting a data file export destination

3.5.2.1 Generated data files

Table 3.5.2.1 lists data files to be generated. For details about generated TP programs, please refer to Appendix C “Sample TP Programs”.

Table 3.5.2.1 Generated data files

File	Description
DM_{Part Name}.TP	Main program which automatically generates a deburring path
BG_{Part Name}_T1 to BG_{Part Name}_T3.TP	Subprograms which measure the positions of the three targets on the workpiece
DG_{Part Name}_{Edge Index}.TP	Subprogram which detects each edge and automatically generates a deburring path
DS_{Part Name}.TP	Main program which performs deburring with contouring operation under force control
CM_{Part Name}.TP	Main program which automatically generates a program for updating data files
CG_{Part Name}_{Edge Index}.TP	Subprogram which automatically generates a program for detecting each edge and updates data files
CS_{Part Name}.TP	Main program which updates data files with contouring operation under force control
{Part Name}_V1.VD to {Part Name}_V3.VD	*i*RVision Vision Processes for detecting three targets on a part. If these vision processes do not exist, they are newly generated and output. If they already exist, those existing vision processes are output.
{Part Name}_DB.VD	*i*RVision vision process for detecting an edge. If this vision process does not exist, it is newly generated and output. If it already exists, that existing vision process is output.
PTP_{Part Name}_EDG.DT PTP_{Part Name}_{Edge Index}_MAS.DT PTP_{Part Name}_{Edge Index}_INI.DT PTP_{Part Name}_{Edge Index}_PRM.DT	Edge data files which contain information including the number, name, and shape data of each edge, orientation of the tool at each position on the edge, and parameter setting for the edge.

⚠ **CAUTION**

1 Generated data files are automatically loaded onto the virtual robot.
2 After adding a target edge for deburring, click the "Export Data Files" button and update all data files for the workpiece.

3.5.2.2 If data file generation fails

When an attempt is made to generate data files, a check is made to see whether the robot can reach the target and edge measurement points. If there is any target or edge measurement point that cannot be reached by the robot, the window like the one shown in Fig. 3.5.2.2(a) appears and the generation of data files fails. (Fig. 3.5.2.2(b))

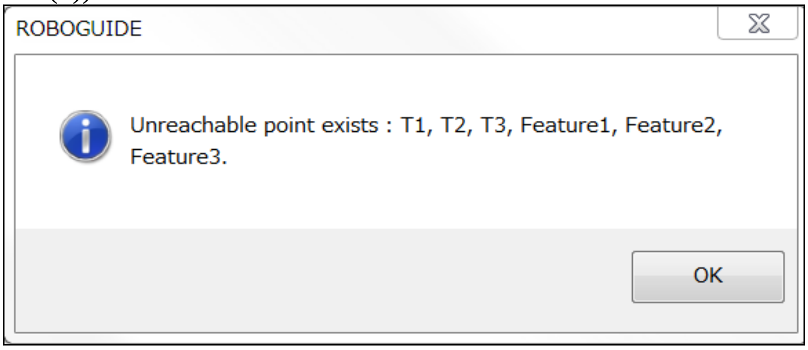


Fig. 3.5.2.2(a) When an unreachable target or edge measurement point exists

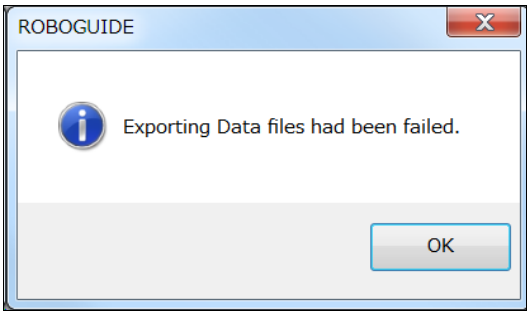


Fig. 3.5.2.2(b) Exporting of data files fails

In this case, make the following adjustments and export the data files again.

- Teach the configuration of the robot's current position to (N,U,T,0,0,0) or some other appropriate configuration.
- If a target measurement point (e.g., T1) cannot be reached, adjust the posture of the target (around Z), or set the target to another feature (e.g., hole). (See Section 3.4, "SETTING TARGETS".)
- If an edge measurement point cannot be reached, change the start point of the edge and teach the edge again (see Subsection 3.3.1, "Drawing an Edge") or adjust "Camera Rotation".

3.5.3 Loading Data Files

Press the "MENU" → "7 FILE" → "1 File" key on the teach pendant to open the "File" screen. On this screen, load data files contained in a medium such as a USB memory onto the online robot controller. For the operation method, refer to Chapter 8, "FILE INPUT/OUTPUT" of "R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR’S MANUAL (Basic Operation) B-83284EN".
You can also transfer data files generated by using ROBOGUIDE to the robot controller via the FTP, or PC share. For the transfer method, refer to "R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate CONTROLLER Ethernet Function OPERATOR’S MANUAL B-82974EN".

> ⚠ **CAUTION**
> 1 When an edge data file (DT file) or vision process (VD file) to be loaded is found in the online robot controller, the file in the controller is overwritten.
> 2 If a data file of a version unavailable with the software on the online robot controller is loaded onto the controller, an error may occur during online running.

4 ONLINE TEACHING WITH THE ROBOT

Before the online running on the robot, you need to teach the *i*RVision vision data online. This chapter describes the procedure for the online teaching with the robot.

Perform the online teaching according to the procedures below.

1 Teaching the *i*RVision camera setup and camera calibration
Before teaching the *i*RVision vision process, you need to set up and calibrate the camera (robot-mounted camera or fixed camera). For information about how to set up and calibrate the camera, refer to "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision 3D Laser Vision Sensor Application OPERATOR’S MANUAL B-83304EN-2" when using a 3D Laser Vision Sensor, or "R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RVision 2D Vision Application OPERATOR’S MANUAL B-83304EN-1" when using a camera.
2 Teaching the target finding vision process
Teach the vision process for finding the target. For details, see Section 4.1, "TEACHING THE TARGET FINDING VISION PROCESS".
3 Teaching the *i*RVision Deburring Line Output Vision Process
Teach the vision process for finding edges and outputing deburring lines. For details, see Section 4.2, "TEACHING THE DEBURRING LINE OUTPUT VISION PROCESS".

TIPS
The camera calibration data generated by ROBOGUIDE cannot be applied to the online robot. For each online robot, the camera setup and camera calibration data need to be created and the camera calibration needs to be executed again.

4.1 TEACHING THE TARGET FINDING VISION PROCESS

Move the robot to the finding point of each target, and teach the vision process to find the target by using *i*RVision 3DL Single-View Vision Process or 2-D Single-View Vision Process. Move the robot to the finding point by executing subprogram BG_{Part Name}_T1.TP to BG_{Part Name}_T3.TP, which finds the base position of the workpiece, in step mode.

Teach the vision processes {Part Name}_V1.VD to {Part Name}_V3.VD created by ROBOGUIDE. For the teaching method, refer to Chapter 4, "2D SINGLE VIEW VISION PROCESS" of "R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RVision 2D Vision Application OPERATOR’S MANUAL B-83304EN-1" or Chapter 4, "3DL SINGLE-VIEW VISION PROCESS" of "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision 3D Laser Vision Sensor Application OPERATOR’S MANUAL B-83304EN-2".

⚠ CAUTION
Make sure that the teaching points of the subprogram to find the workpiece base position generated with ROBOGUIDE are within the range of the actual robot motion and that the robot does not interfere with any of the peripheral equipment as it moves to each teaching point.

When teaching the vision process, note the following two points.

- Set the offset mode of the vision process to "Found Position (User)" or "Fixed Frame Offset". (Fig. 4.1(a))

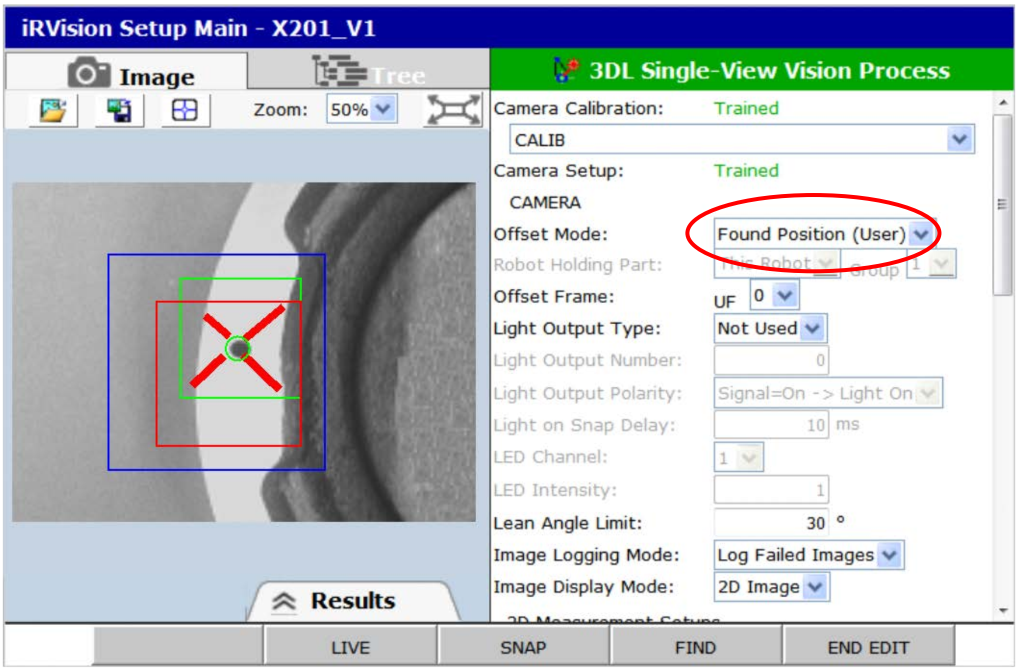


Fig. 4.1(a) Teaching the target finding vision process

- Set the origin of the GPM Locator Tool as appropriate for the position of the target set with ROBOGUIDE (for example, the center of the machined hole). (Fig. 4.1(b))

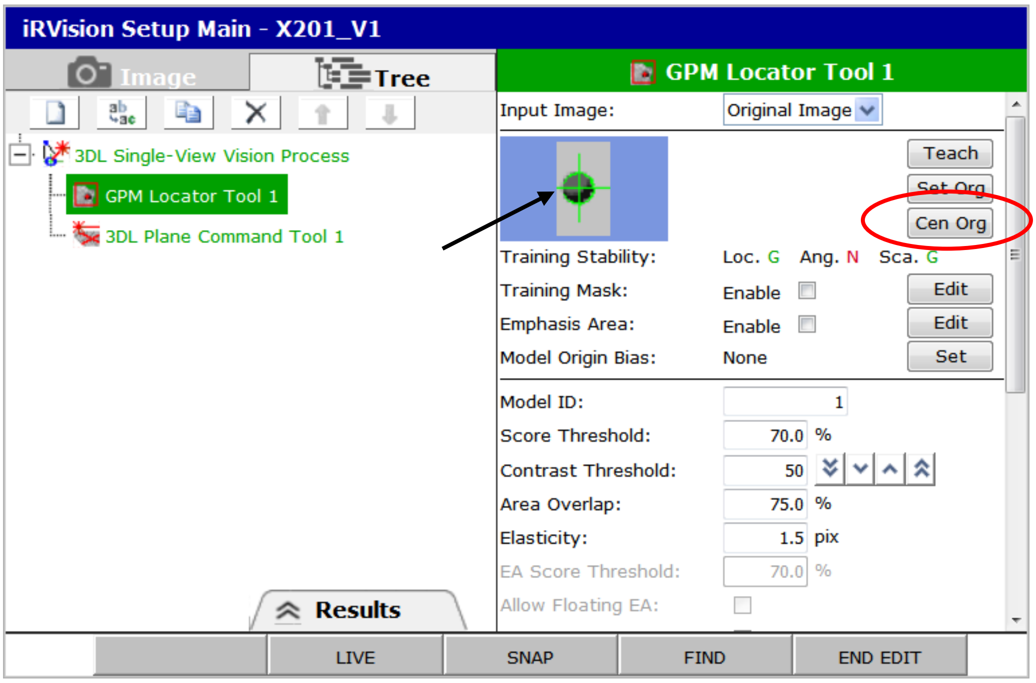


Fig. 4.1(b) Teaching the origin

4.2 TEACHING THE *i*RVision DEBURRING LINE OUTPUT VISION PROCESS

The *i*RVision Deburring Line Output function outputs edges found in a camera-captured image as deburring lines. Edges are found in the neighborhood of the edge data generated with ROBOGUIDE. The output deburring lines are used for Deburring Path Auto Generation (see Section 5.1, "DEBURRING PATH AUTO GENERATION").

Before teaching the deburring line output vision process, move the robot to the finding point of the workpiece edge. Move the robot to the finding point according to the procedures below.

1 Execute the three subprograms BG_{Part Name}_T1.TP to BG_{Part Name}_T3.TP, which find the base position of the workpiece, till the end.
2 Execute subprogram DG_{Part Name}_{Edge Index}.TP, which finds edges and performs deburring path auto generation, in step mode in order to move the robot to the first point where vision detection is executed.

After moving the robot to the finding point, teach the vision process and Command Tool of the *i*RVision Deburring Line Output function according to the procedures below.

> ⚠ **CAUTION**
> Make sure that the finding point of the workpiece edge generated with ROBOGUIDE is within the range of the actual robot motion and that the robot does not interfere with any of the peripheral equipment as it moves to the edge finding point.

4.2.1 Teaching the Vision Process

Place the cursor on the created *i*RVision Deburring Line Output Vision Process (e.g., {Part Name}_DB.VD) and press F3"EDIT" to open the screen for editing the deburring line output vision process. (Fig. 4.2.1(a))

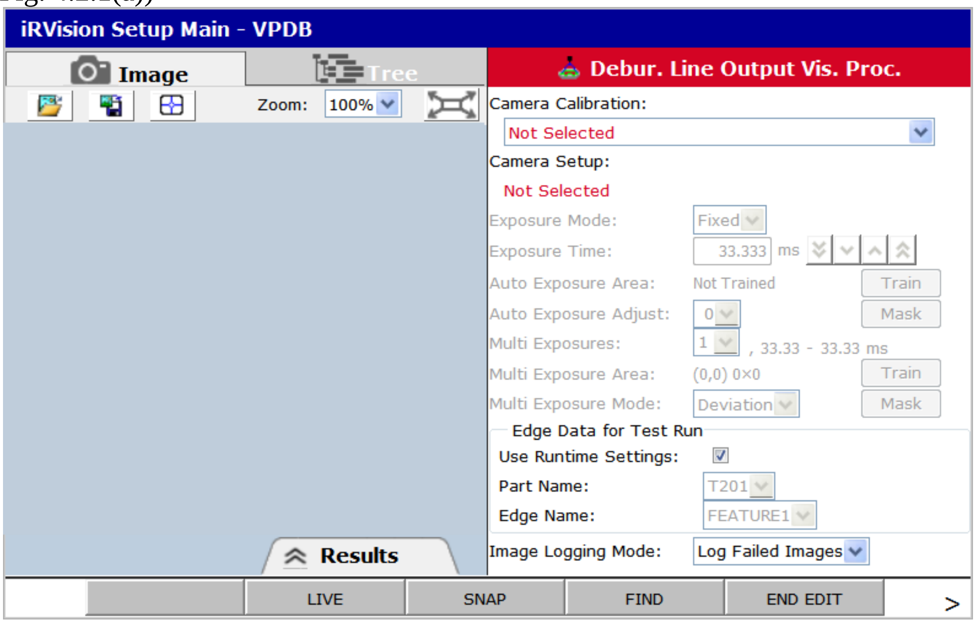


Fig. 4.2.1(a) Screen for editing the deburring line output vision process

Click the "Tree" tab to display the tree view. (Fig. 4.2.1(b)) In this screen, change the values or settings of the items mentioned below.

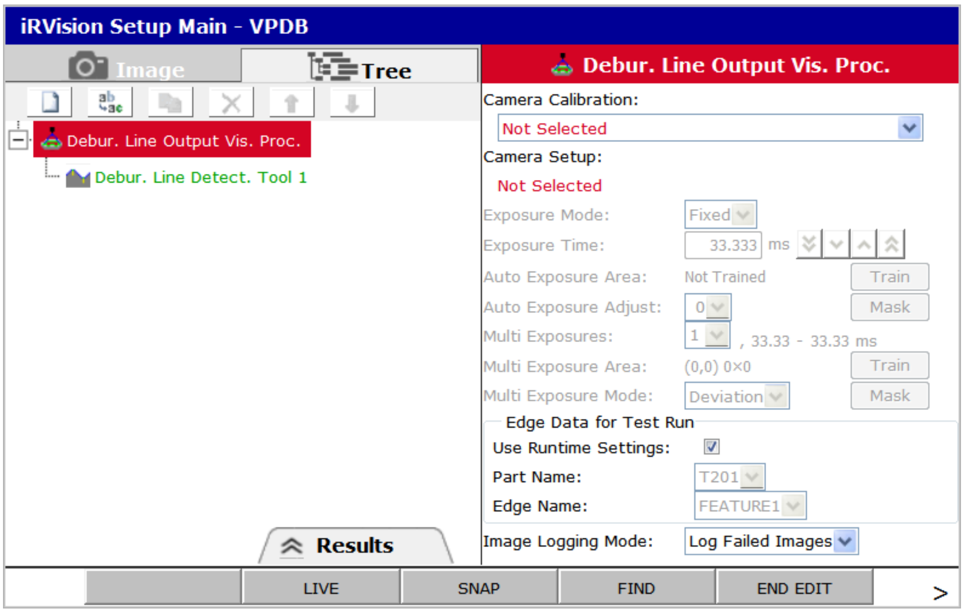


Fig. 4.2.1(b) Tree view for the deburring line output vision process

Camera Calibration

Select the camera calibration to be used. Grid Pattern Calibration Tool, 3DL Calibration Tool, and Robot-Generated Grid Cal. Tool are available.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Exposure Time

Set the exposure time of the camera to be used at runtime. For information about the other settings related to the exposure time and exposure mode, refer to Subsection 3.7.11, "Setting Exposure Mode" of "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference) B-83304EN".

Use Runtime Settings

If you check this box, the edge data set in the KAREL program PTPINIT is used when you run a test on the setup screen, in the same way as at runtime. (For information about PTPINIT, see Section C.1.3, "DG_{Part Name}_{Edge Index}.TP.") If this box is checked, you cannot set the part name and edge name in the edge data.

Part Name and Edge Name

If you do not check the "Use Runtime Settings" box, select the part name and edge name in the edge data to be used for the test run on the setup screen. The test run will be performed using the edge data selected here. Note that the edge data selected here is used only when the test run is performed on the setup screen. When the vision process is executed from a TP program, the edge data specified by PTPINIT is used, instead of the edge data selected here.

Image Logging Mode

Specify whether to log images during the execution of the process. Note that, if the *i*RVision system is configured not to create vision logs in the Vision Config screen, no images are logged.

- Do Not Log
  Images are not logged.
- Log Failed Images
  Only failed images are logged.
- Log All Images

All images are logged.

For information about vision logs, refer to Section 3.3, "VISION LOG" of "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference) B-83304EN".

> ⚠ **CAUTION**
> The execution of the next vision process cannot be started until the image logging of the last vision process is completed. The time required for image logging differs depending on the device used. Check whether there is no operational problem before using it.

4.2.1.1 Test run

Move the camera above the workpiece, uncheck the "Use Runtime Settings" box, and select a part name and edge name. In the edit screen for the deburring line output vision process, press F4"FIND" to perform a test run and check whether edges can be found. In "Results", the items mentioned below are displayed.

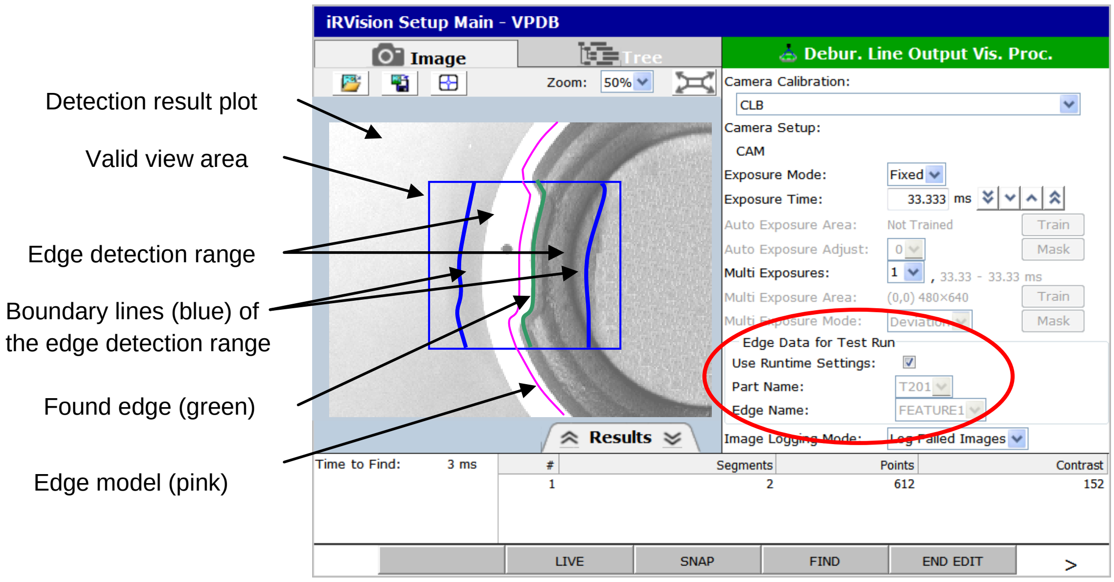


Fig. 4.2.1.1 Detection result

Time to Find

The time it took to find the edge is displayed in milliseconds.

Results

The following values are displayed.

- Segments
  Number of segments of the found edge
- Points
  Number of points extracted from the found edge
- Contrast
  Average contrast of the found edge

Detection result plotting

The detection result is plotted on the image. The edges found in the image are displayed in green, the model (edge data created with ROBOGUIDE) in magenta, and the edge detection range in blue. To determine which to be displayed, select the result plot mode. For details of the result plot mode, see Section 4.2.3, "Teaching the Command Tool".

4.2.2 Teaching the Command Tool

If you select "Debur. Line Detect. Tool 1" as the deburring line detection tool in the tree view of the edit screen for the deburring line output vision process, the setup screen for the deburring line detection tool is displayed. (Fig. 4.2.2)
The deburring line detection tool extracts all workpiece edges from the camera-captured image. It can be used only for the deburring line output vision process.

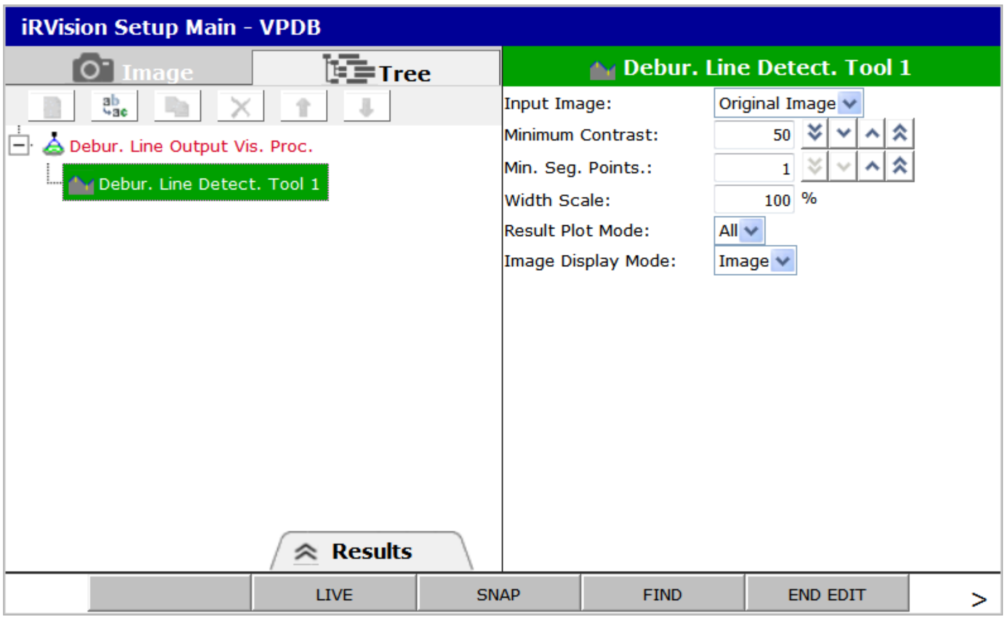


Fig. 4.2.2 Deburring line detection tool

Input Image

Select the image which is used for training model and detection. When the vision process has an Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this GPM Locator Tool, instead of the camera snapped original image. For details, refer to Sections 7.25, "Image Preprocess Tool", 7.26, "Image Filter Tool", and 7.27, "Color Extraction Tool" of "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference) B-83304EN".

Minimum Contrast

Specify the minimum permissible grayscale contrast for the search. If you set a small value, this detection tool will be able to find the deburring line in obscure images as well but take longer to complete the location process. If this detection tool tends to inadequately find blemishes and other unwanted edges with low contrast, try setting a larger value. Those image features whose contrast is lower than the specified value are ignored.

Min. Seg. Points.

Specify the minimum permissible number of segment points to be detected. If the number of detected segment points is smaller than this value, the segment is considered to have failed to be detected.

Width Scale

Specify the scale used to adjust the detection width (shape tolerance) specified in the edge data.

Result Plot Mode

Select how the detection result is displayed on the image during the execution of the process.

- Edge
  Only the detected edge is displayed.
- Edge + Model

Only the detected edge and edge model are displayed.

- Edge + Bound
  Only the detected edge and the boundary lines of the edge detection range are displayed.
- All
  The detected edge, edge model, and boundary lines of the edge detection range are displayed.

Image Display Mode

Select the image display mode for the edit screen.

- Image
  Only the camera image is displayed.
- Image + Results
  The camera image and detection test results are displayed.
- Image + Edges
  The camera image and the edges in the image are displayed.

4.2.2.1 Test run

In the setup screen for the deburring line detection command tool, press F4"FIND" to perform a test run and check whether the process is executed as expected.

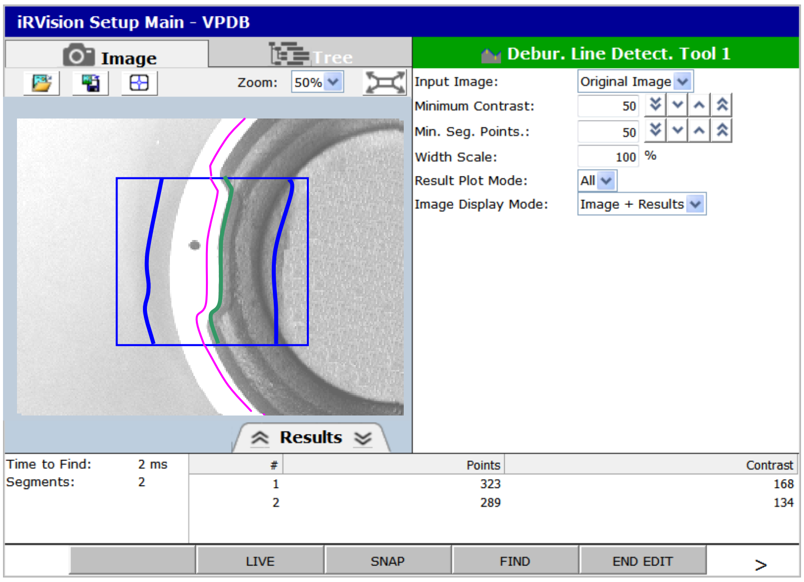


Fig. 4.2.2.1 Detection result

Time to Find

The time it took for detection is displayed in milliseconds.

Segments

The number of segments in the detected deburring line is displayed.

Detection result table

The following values are displayed.

- Points
  Number of points in the segment
- Contrast
  Average contrast of the segment

5 ONLINE RUNNING ON THE ROBOT

In the online running of the robot, the main program for deburring path auto generation is executed, the base position for an actual workpiece and the 3D point sequence of an edge are detected by *i*RVision, a deburring path (TP program for deburring) is automatically generated. Then, deburring is performed through force control contouring.

This chapter describes the procedure for the online running on the robot.
1 Deburring path auto generation
2 Force control deburring

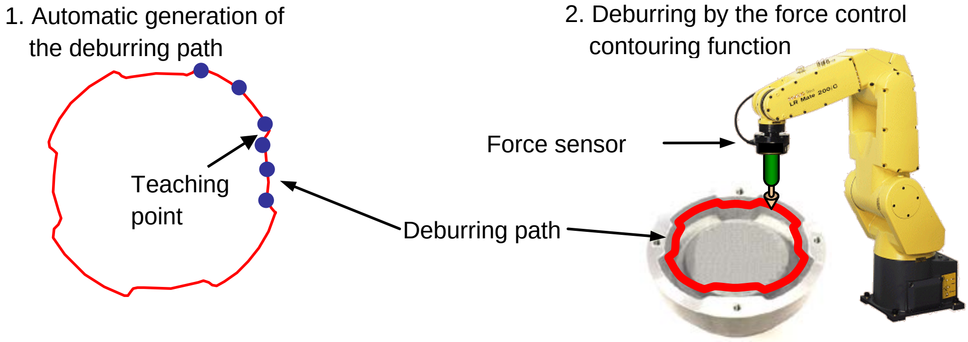


Fig. 5 Online running procedure on the robot side

5.1 DEBURRING PATH AUTO GENERATION

When main program DM_{Part Name}.TP, which automatically generates a deburring path, is executed, *i*RVision detects the base position and edges of the workpiece and a deburring program (deburring path) is automatically generated. For details about the deburring path, please refer to Appendix C “Sample TP Programs”.

Fig. 5.1 shows the flow of deburring path auto generation.
1 Subprogram BG_{Part Name}_T1.TP to BG_{Part Name}_T3.TP, which find the base position of the workpiece, and subprograms DG_{Part Name}_{Edge Index}.TP, which detect each edge and automatically generates each deburring path, are called from main program DM_{Part Name}.TP, which automatically generates a deburring path.
2 Target finding vision processes (e.g., {Part Name}_V1.VD to {Part Name}_V3.VD) are called from BG_{Part Name}_T1.TP to BG_{Part Name}_T3.TP to find three targets, thus obtaining the base position of the workpiece.
3 A deburring line output vision process (e.g., {Part Name}_DB.VD) is called from DG_{Part Name}_{Edge Index}.TP to detect the 3D point sequence of the actual edge. By use of the 3D point sequence of the actual edge, the ROBOGUIDE-generated edge data such as shape data, and the parameters for orientation handling and deburr path generation, subprogram DU_{Part Name}_{Edge Index}.TP), which deburrs an individual edge through force control contouring, is automatically generated.

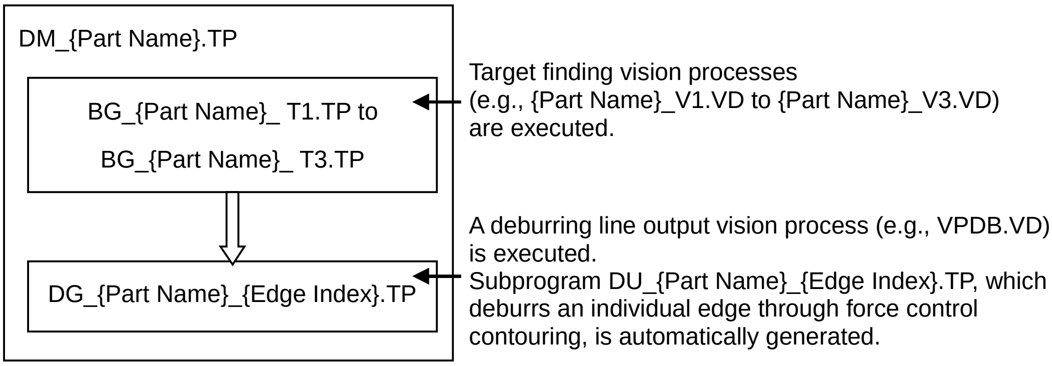


Fig. 5.1 Flow of deburring path auto generation

> ⚠ **CAUTION**
> Make sure that the teaching points of the subprogram generated by ROBOGUIDE are within the range of the actual robot motion and that the robot does not interfere with any of the peripheral equipment as it moves to each teaching point.

5.2 FORCE CONTROL DEBURRING

When main program DS_{Part Name}.TP, which performs deburring through force control contouring, is executed, deburring is performed through force control contouring. For details about TP programs, please refer to Appendix C “Sample TP Programs”.

Fig. 5.2 shows the flow of deburring.

1 DU_{Part Name}_{Edge Index}.TP generated in Section 5.1 is called from DS_{Part Name}.TP.
2 Through force control contouring, DU_{Part Name}_{Edge Index}.TP moves the Deburring Tool along each edge while holding it down with the preset force to deburr the workpiece edge.

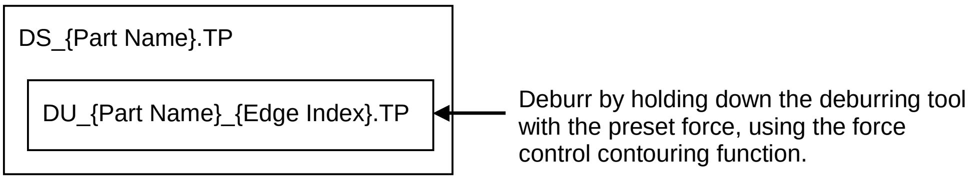


Fig. 5.2 Flow of deburring

> ⚠ **CAUTIOIN**
> Make sure that the robot does not interfere with any of the peripheral equipment as it moves to the deburring path of a machined surface.

5.2.1 Adjusting the Parameters

You can adjust the parameters for deburring path generation and force control contouring, as necessary, according to the procedures below.

1 Select "MENU" → "1 UTILITIES" → "3 Force Sensor" → "5 Deburring Path Auto Generation" to display the "Deburr Path Auto Gen/Part List" screen (Fig. 5.2.1(a)). This screen lists all the part data loaded to the controller.

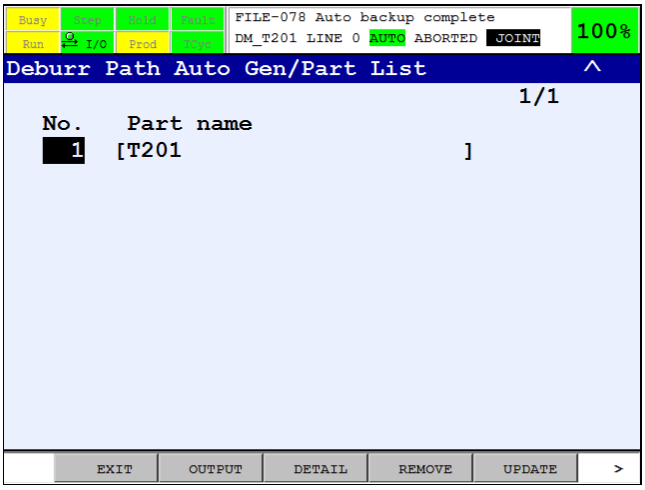


Fig. 5.2.1(a) Part List screen

> **HINT**
> The part list is created by automatically searching the specified data path for part data files, only when you open the Part List screen for the first time after turning on the power of the controller. Even if you load new edge data to the controller via a memory card or USB memory device later, the part list is not updated automatically. Pressing the "F5 UPDATE" button updates the part list. Note also that the "Part List" screen cannot be displayed during online running.

Function keys

The function keys that are used are as follows.

Key	Display name	Description
F1	EXIT	Returns to the UTILITIES screen of the force sensor.
F2	OUTPUT	Outputs the part data.
F3	DETAIL	Displays the Edge List screen.
F4	REMOVE	Removes the data file (TP program and edge data) of the selected part.
F5	UPDATE	Updates the part data list manually.
F6	DATA PTH	Displays the data path setting screen.

2 If you select a part on the Part List screen and press the Enter or "F3 DETAIL" key, the Edge List screen for the selected part is displayed (Fig. 5.2.1(b)).

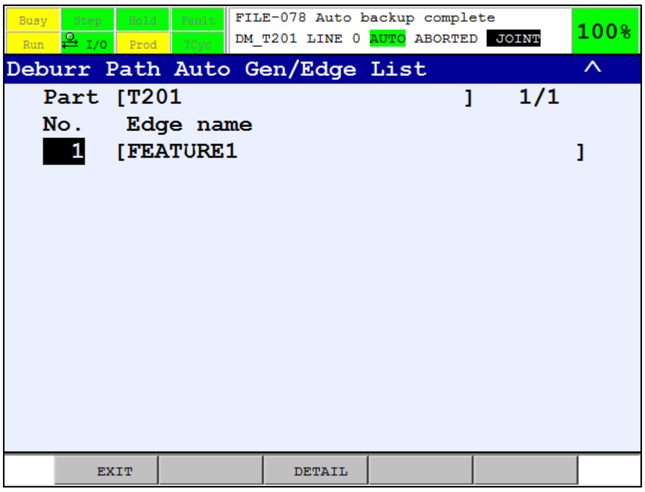


Fig. 5.2.1(b) Edge List screen

Function keys

The function keys that are used are as follows.

Key	Display name	Description
F1	EXIT	Returns to the Part List screen.
F3	DETAIL	Displays the parameter setting screen for an edge.

3 If you select an edge on the Edge List screen and press the Enter or F3"DETAIL" key, the parameters for the selected edge are displayed.

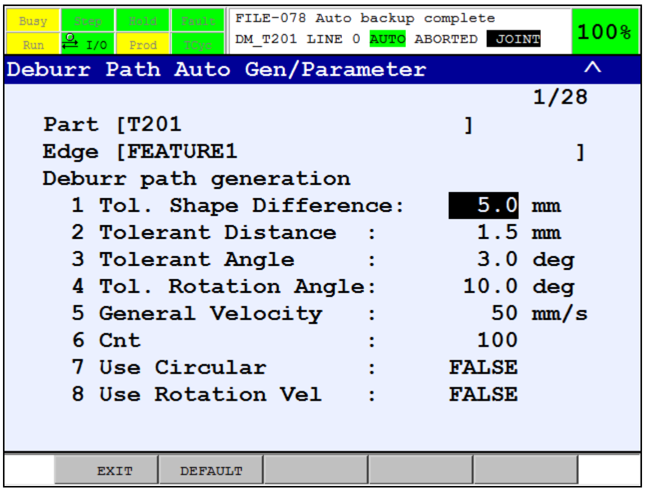


Fig. 5.2.1(c) Parameter setting screen

If you change any of the parameter values in this screen, the data file stored in the controller is updated accordingly. The parameters you can change in this screen are listed below. (The part name and edge name cannot be changed.)

Deburr Path Generation

1 Non Stop When Gen. Fail
2 Shape Tolerance
3 Distance Threshold
4 Angle Threshold
5 Orient Change Threshold
6 General Velocity
7 Cnt
8 Use Circular Command
9 Use Angular Velocity
10 Angular Velocity
11 Edge Offset
12 Edge End Extension
13 Above Approach Point Vel
14 Leave Point Velocity
Approach Pnt To First Edge Pnt Dist
15 Trvl Dir at First Pnt
16 Push Dir at First Pnt
Last Edge Point to Leave Point Dist
17 Trvl Dir at Last Pnt
18 Push Dir at Last Pnt
19 Vrt to Machined Surf
20 Pos Record Interval

Contouring Schedule

21 Schedule Number
22 Pushing Dir.
23 Contact F Threshold
24 Approach Velocity
25 Contouring Force
26 FC Gain (Master Freq.)
27 Pushing Dir. Velocity
28 Push Dir. Offset Angle
29 Offset Push Dir. With PR

Tool Setting

30 UTool
31 Tool Radius at Contact P
32 TCP to Machined Surf Dis

For detailed descriptions of "Deburr Path Generation", "Contouring Schedule", and "Tool Setting", see Subsection 3.1.4.3, "Setting Deburr Path Generation", Subsection 3.1.4.4, "Setting Contouring schedule", and Subsection 3.5.1.1, "Setting tool-related items". For information about "22 Pushing Dir." of "Contouring Schedule", see Subsection 3.5.1.1, "Setting tool-related items".

Function keys

The function keys that are used are as follows.

Key	Display name	Description
F1	EXIT	Returns to the Edge List screen.
F2	DEFAULT	Resets the parameter values to defaults.

5.2.2 Automatic Contouring Schedule Setting

During the online running of the robot, the specified force control schedule is automatically taught.

> ⚠ **CAUTION**
> The specified force control schedule needs to be "Unused" or "Contouring" previously used by this function.

1 The "Unused" force control schedule specified by ROBOGUIDE (Schedule [10] by default) is automatically taught as "Contouring". The comment of the schedule is also set to "!ForDeburrOnly!" automatically. (Fig. 5.2.2) If the specified force control schedule is already set as another function (e.g., “Shaft Insertion”) or manually set as the “Contouring” function, an alarm is issued during online running.

2 If the "Contouring End" schedule does not exist, an "Unused" schedule having the largest number is automatically taught as "Contouring End". If all force control schedules are set as functions other than "Contouring End", an alarm is issued during online running. For information about the Contouring and Contouring End schedule, refer to Subsection 3.5, "Schedule Data" or 3.5.7, “Contouring Function” of "R-30*i*B/R-30*i*B Mate CONTROLLER Force Sensor OPERATOR’S MANUAL B-83424EN".

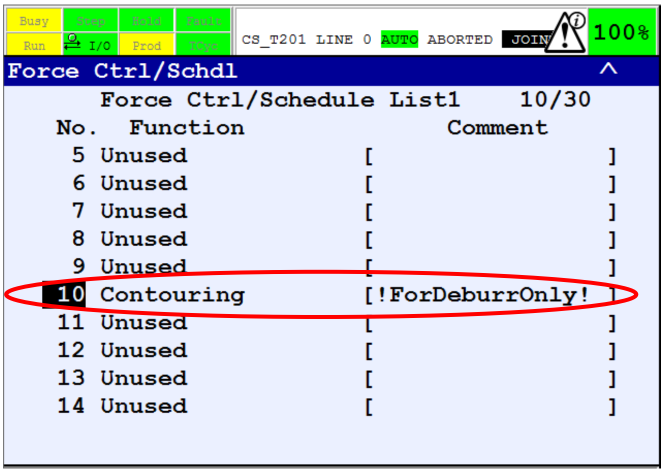


Fig. 5.2.2 Automatic Contouring Schedule Setting

3 During the online running of the robot, some of the contouring schedule parameters are automatically set, as described below. For information about the tool spin, see Subsection 3.1.4.1, "Setting position defaults". For information about the contouring schedule parameters, refer to Subsection 3.5.7.6, "Parameters" of "R-30*i*B/R-30*i*B Mate CONTROLLER Force Sensor OPERATOR’S MANUAL B-83424EN".

In the case of "Fixed tool spin, keep normal"

- "Control Frame" is set to "User Frame".
- "User Frame No." is the same as the user frame number specified with ROBOGUIDE.
- "User Frame Compensation" is set to "OFF".
- "Pushing Dir Auto Chg" is set to "UserFrame X-Y".

In the case of "Change tool spin along path, keep normal"

- "Control Frame" is set to "Tool Frame".
- "Tool Frame No." is the same as the tool frame number specified with ROBOGUIDE.
- "User Frame Compensation" is set to "OFF".
- "Pushing Dir Auto Chg" is set to "OFF".

APPENDIX

A TROUBLESHOOTING

A.1 *i*RVision DEBURRING LINE OUTPUT VISION PROCESS

A.1.1 Measures to Take If Find Edge Fails

If finding edges fails, open the vision log of *i*RVision, check the image brightness and so on, and manually adjust the exposure time in the vision process, as well as the imaging position and so on with the TP program. For information about the vision log, refer to Section 3.3, "VISION LOG" of "R-30*i*B/R-30*i*B Mate CONTROLLER iRVision OPERATOR'S MANUAL (Reference) B-83304EN".

A.1.2 Vision Override of Parameters

Of the setting parameters for the *i*RVision Deburring Line Output vision processes or command tools, the following parameters can be specified for vision override, and be rewritten from the robot program during execution. For details of vision override, refer to Section 8.1, "VISION OVERRIDE" and Subsection 9.2.2.8, "Override" of "R-30*i*B/R-30*i*B Mate CONTROLLER iRVision OPERATOR'S MANUAL (Reference) B-83304EN".

Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

Contrast Threshold

Specify a value between 1 and 200.

Segment Points Threshold

Specify a value between 1 and 1000.

Width Scale

Specify a value between 0.1 and 5.0.

A.2 DEBURRING PATH AUTO GENERATION

A.2.1 If the Shapes of the Actual Workpiece and the CAD Model Differ Greatly

If the shape of the actual workpiece and the CAD model differ greatly, it is recommended to update the data file for the workpiece with the procedure below.

- Execute CM_{Part Name}.TP on the actual workpiece, use iRVision to detect the base position and the edges of the workpiece, and generate a subprogram for updating the data file for each edge, CT_{Part Name}_{Edge Index}.TP, and a subprogram for recording the robot position, CTRMONIT.TP. Then, reduce the override so that the general velocity becomes 10 mm/s or less, execute CS_{Part Name}.TP to contour the edges with force control contouring function and update the part data file.

A.2.2 If you Want to Fine-Adjust the Orientation of the Tool during Deburring

If you want to fine-adjust the orientation of the tool during deburring, adjust it while checking the edge teaching points in CT_{Part Name}_{Edge Index}.TP in step mode, then reduce the override so that the general velocity becomes 10 mm/s or less, execute CS_{Part Name}.TP, record the position and orientation of the tool while contouring the edges with force control contouring operation, and update the part data file.

A.2.3 Changing the Locations for Saving Edge Data Files and Vision Data Files

If edge data files or vision data files are so large that they exceed the capacity of the controller, the data files can be stored to an external unit (Memory Card or USB memory).
The location for saving data files can be changed with the procedures below.

1 Select "MENU" → "1 UTILITIES" → "3 Force Sensor" → "5 Deburring Path Auto Generation" to display the "Deburr Path Auto Gen/Part List" screen.

2 On the Part List screen, press "F→" → F1"DATA PATH", and the data path setting screen appears. (Fig. A.2.3)

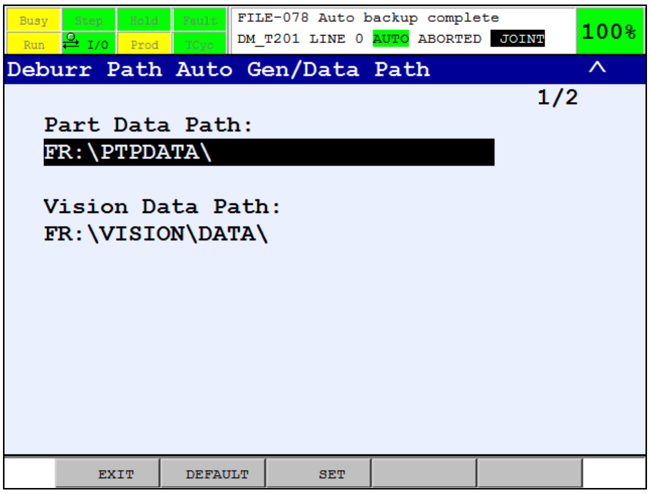


Fig. A.2.3 Data path setting screen

Function keys

The function keys to use are as listed below.

Key	Display name	Description
F1	EXIT	Return to the force sensor utility screen.
F2	DEFAULT	Return the data path value to the default value (data path shown in Fig. A.2.3).
F3	SET	Set a data path value.

3 On the data path setting screen, the locations for saving edge data files and vision data files can be changed to a Memory Card (MC:¥) or a USB memory (UD1:¥). For example, if the location for saving edge data files is changed to “MC:¥PTPDATA¥” and the location for saving vision data files is changed to “MC:¥VISION¥”, and F3"SET" is pressed, the message, "Change data path and move data?", appears.

- If you press "F4 YES", the data path is changed, and the data files are moved to the specified location. If, however, the saving device is set to other than “FR:¥”, “MC:¥”, and “UD1:¥” or if the path name is incorrect, an alarm message appears, and the saving location returns to the original one. If the location for saving vision data files is changed, a message appears asking to confirm whether to restart the controller.
- If you press "F5 NO" or the "Back" key, the data path is not changed.

> ⚠ **CAUTION**
> If saving edge data files or vision data files to an external storage unit (Memory Card (MC:¥) or USB memory (UD1:¥)), do not pull out the external storage unit when the power of the controller is on.

A.2.4 Changing the Location for Saving TP Programs

If the TPP area of the CMOS is not sufficient, the TP program can be saved to SHADOW or FILE (external storage unit such as Memory Card (MC:¥) or USB memory (UD1:¥)) by using the TP dram/file storage function. For details, refer to "29 TP DRAM/FILE STORAGE FUNCTION" of "R-30iB/R-30iB Mate CONTROLLER Optional Function OPERATOR'S MANUAL B-83284EN-2.

A.2.5 Saving Data Files

If "All Backup" is performed on the controller, the data files for all parts are backed up.
With the procedures below, the data file for a specified part can be saved to a Memory Card (MC:¥) or a USB memory (UD1:¥).

1. Select "MENU" → "1 UTILITIES" → "3 Force Sensor" → "5 Deburring Path Auto Generation" to display the "Deburr Path Auto Gen/Part List" screen.
2. On the Part List screen, position the cursor on the part for which the data file is to be output, press F3"OUTPUT", and the "Output Data" screen appears.
3. On the "Output Data" screen, specify the output location (Memory Card (MC:¥) or USB memory (UD1:¥)), and press F3"OUTPUT", the data file for the part can be saved to a Memory Card (MC:¥) or a USB memory (UD1:¥).

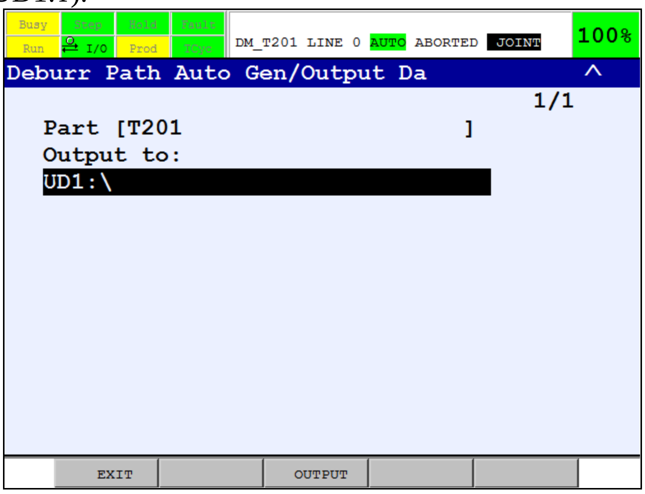


Fig. A.2.5 Data file output screen

Function keys

The function keys to use are as listed below.

Key	Display name	Description
F1	EXIT	Return to the Part List screen.
F3	OUTPUT	Output data files.

A.3 DEBURRING WITH FORCE CONTROL

A.3.1 Adjusting Parameters

If some problems occur when deburring an actual workpiece by using the force control contouring function, adjust the parameters on the "Deburr Path Auto Gen/Parameter" screen. For how to set parameters, see Subsection "5.2.1, "Adjusting the Parameters".

1 If the point at which the Deburring Tool first touches the edge is far apart from the first edge point, perform one of the operations below.
- Increase the "Approach Velocity" value of "Contouring Schedule".
- Increase the value of "Trvl Dir at First Pnt" of "Approach Pnt To First Edge Pnt Dist" of "Deburr Path Generation".
- Decrease the value of "Push Dir at First Pnt" of "Approach Pnt To First Edge Pnt Dist" of "Deburr Path Generation".

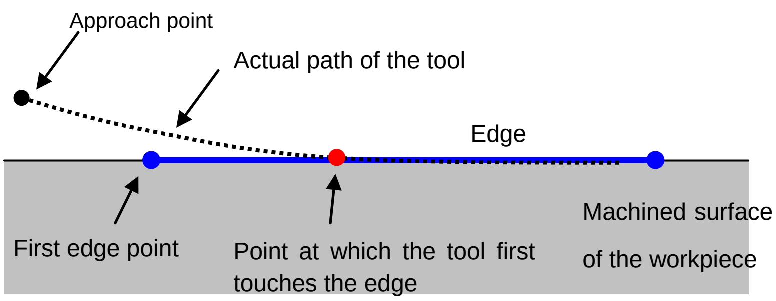


Fig. A.3.1 Point at which the tool first touches the edge

2 If, near the first point of a closed edge, the edge is not cut or the amount of cutting (machined depth) is small, make an adjustment as described below.
- Increase "Edge End Extension" of "Deburr Path Generation".

3 If the Deburring Tool cuts the edge too much near the point at which the tool first touches the edge, and the subsequent amount of cutting the edge is normal, make an adjustment as described below.
- Reduce "Approach Velocity" of "Contouring Schedule".

4 If the tool already touches the edge at the approach point, make an adjustment as described below.
- Increase the value of "Push Dir at First Pnt" of "Approach Pnt To First Edge Pnt Dist" of "Deburr Path Generation".

5 If the amount of cutting the edge (machined depth) is small throughout the edge, perform one of the operations below.
- Increase "Contouring Force" of "Contouring Schedule".
- Reduce "General Velocity" of "Deburr Path Generation".

If the amount of cutting the edge (machined depth) is large, adjust one of the above parameters in the opposite direction.

6 If the amount of cutting the edge (machined depth) is small at some portions of the edge (corners, for example) or if the tool leaves the edge, make an adjustment as described below.
- Increase "FC Gain (Master Freq.)" of "Contouring Schedule".
- Increase "Pushing Dir. Velocity" of "Contouring Schedule".

7 If the tool oscillates during deburring, make an adjustment as described below.
- Reduce "FC Gain (Master Freq.)" of "Contouring Schedule".

B SIMULATING DEBURRING OPERATIONS WITH ROBOGUIDE

This chapter describes the procedures for simulating online running (deburring operations) of the robot with ROBOGUIDE.

1 Restrictive conditions on simulation
2 Camera calibration
3 Teaching vision processes
4 Simulating deburring operations

B.1 RESTRICTIVE CONDITIONS ON SIMULATION

B.1.1 Laser Function of the 3D Laser Vision Sensor

If the 3D Laser Vision Sensor is to be used with ROBOGUIDE, the laser function must be supported. The laser function of the 3D Laser Vision Sensor can be used on a computer on which a graphic board supporting OpenGL1.5 or later version is mounted. A graphic chip optimized for OpenGL, such as the Quadro Series of NVIDIA, is recommended.

Checking the laser function

It can be checked whether the laser function is supported or not on the property page of the 3D Laser Vision Sensor. Press the Test button to check whether the laser is drawn correctly on the workpiece surface. (Fig. B.1.1(a))

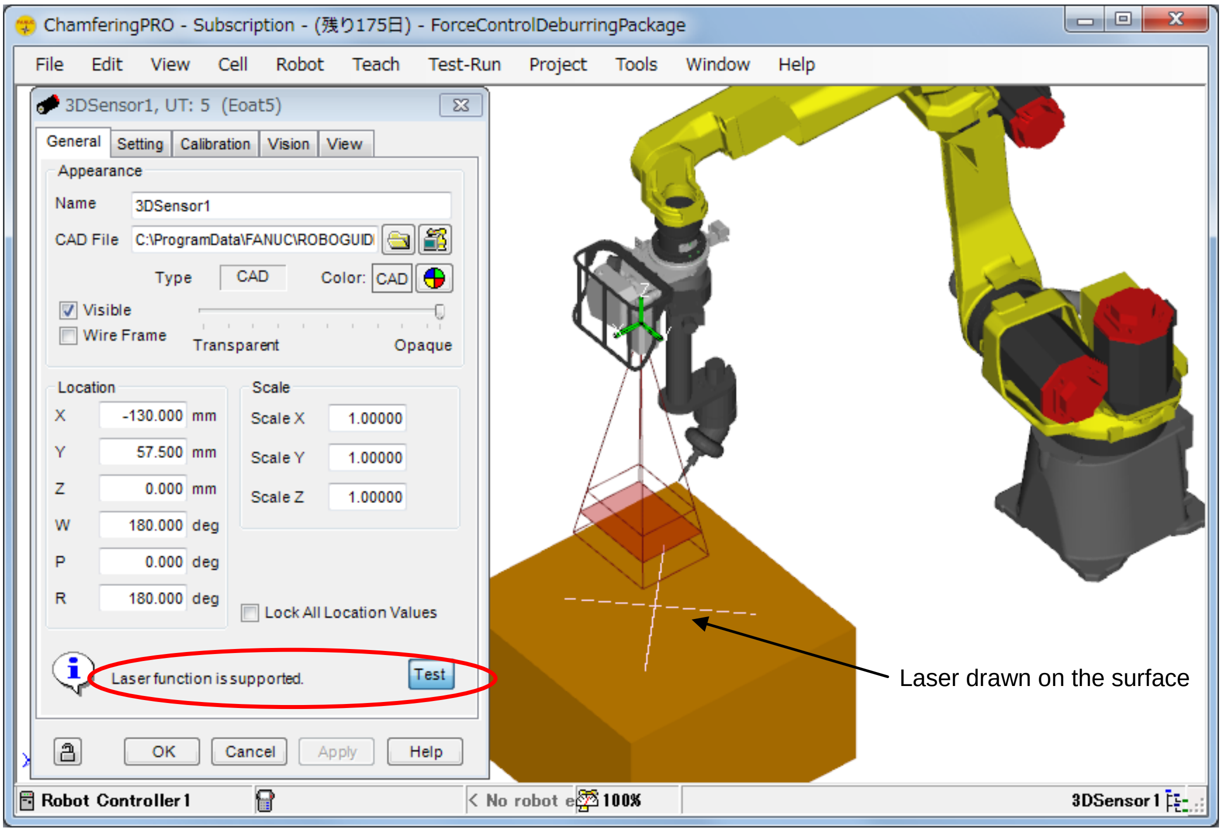


Fig. B.1.1(a) Laser function test

If the laser is not drawn correctly, perform operations according to the procedures below.

1 Press the "Save ROBOGUIDE system information" button on the tool bar, open the generated file PCInfo.txt, and check that the version of OpenGL in it is 1.5 or later. (Fig. B.1.1(b)) If the version of OpenGL is earlier than 1.5, update the graphic chip driver.

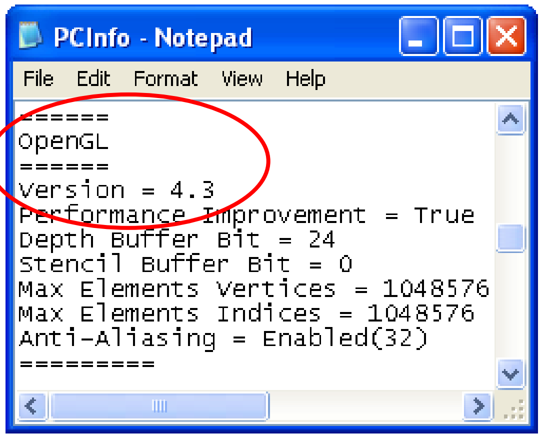


Fig. B.1.1(b) Checking the OpenGL version

2 If the laser is not drawn even though the version of OpenGL is 1.5 or later, select "Tools" → "Options" from the ROBOGUIDE menu, and try mode 1 and 2 for the 3D Laser Vision Sensor mode in the "System" tab on the "Options" screen.

3 If the laser is not drawn even though mode 1 and 2 above are tried, it is necessary to replace the graphic board or use another PC.

B.1.2 Brightness of CAD Models

- If the brightness of the laser-irradiated surface of the CAD model of the part is high, the laser path cannot be recognized on the *i*RVision side in some cases.
- If the brightness of the machined surface of the CAD model of the part is lower than the casted surface or if the brightness contrast of the machined and casted surfaces is low, the edge cannot be found on the *i*RVision side in some cases, disabling the simulation of deburring operations.

B.2 CAMERA CALIBRATION

To simulate the same operation as that of the actual machine on ROBOGUIDE, including finding edge, camera calibration must be performed. There are two ways to perform camera calibration on ROBOGUIDE.

1 Automatically generate calibration data from camera placement information.
2 Perform calibration by using dot patterns.

The first method is explained below.

Automatically Generating Calibration Data from Camera Placement Information

With the procedures below, automatically create calibration data from a robot-mounted camera mounted to the robot wrist (or a fixed camera) to complete camera calibration.
To perform camera calibration on ROBOGUIDE, this way is usually used.

1 In the Setting tab on the vision sensor property page (Fig. B.2(a)), set each of the items under "Attribute".

2 In the Calibration tab (Fig. B.2(b)) on the vision sensor property page, press the "Generate Camera Calibration" button.

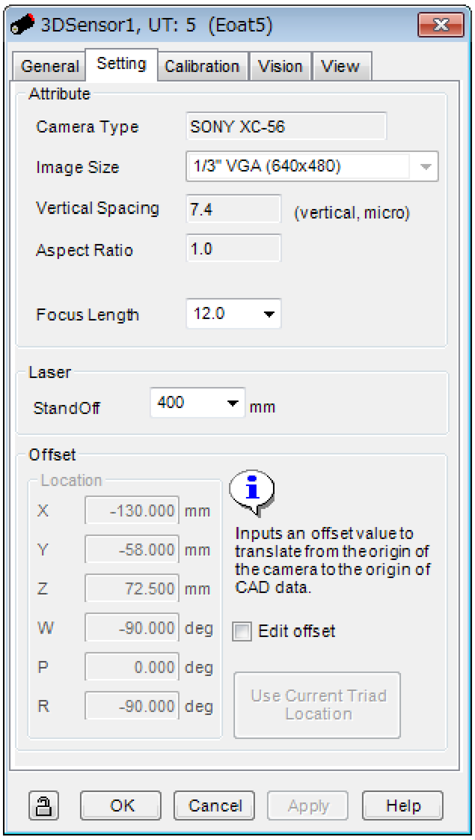


Fig. B.2(a) Setting tab on the vision sensor property page

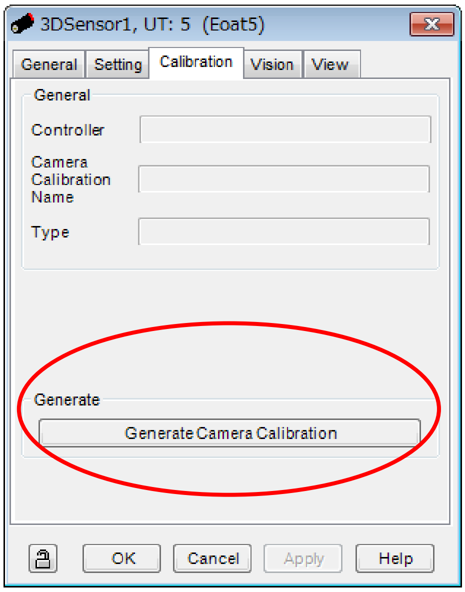


Fig. B.2(b) Generate Camera Calibration

3 On the setting screen for Generate Camera Calibration, specify the Camera Calibration Name, Camera Setup Name, Robot to be offset, and so on, and press the OK button. If using the 3D Laser Vision Sensor, select "3D LASER VISION CALIBRATION" for Calibration Type. (Fig. B.2(c)) For a 2D camera, select "GRID PATTERN CALIBRATION". For "Application Frame", select "UF:0 (No Frame)".

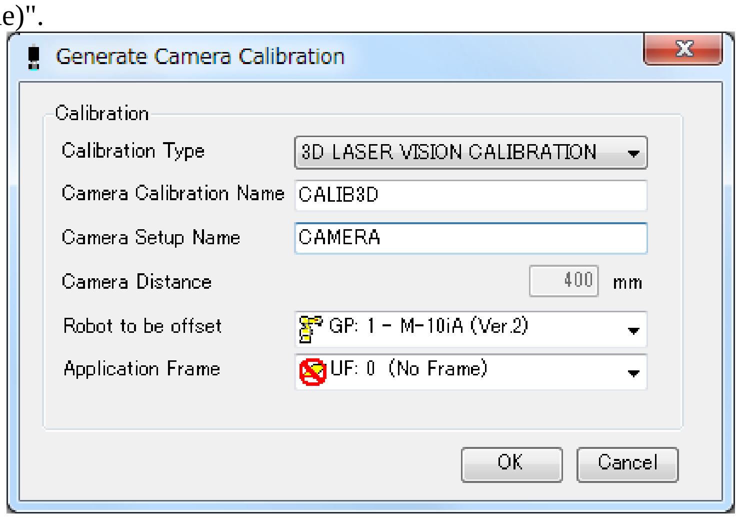


Fig. B.2(c) Setting screen for Generate Camera Calibration

4 Calibration data is automatically calculated and generated from vision sensor placement information, and in the Calibration tab of the vision sensor property page, the calibration data name and type (Object→ Camera Calibration) are displayed. (Fig. B.2(d))

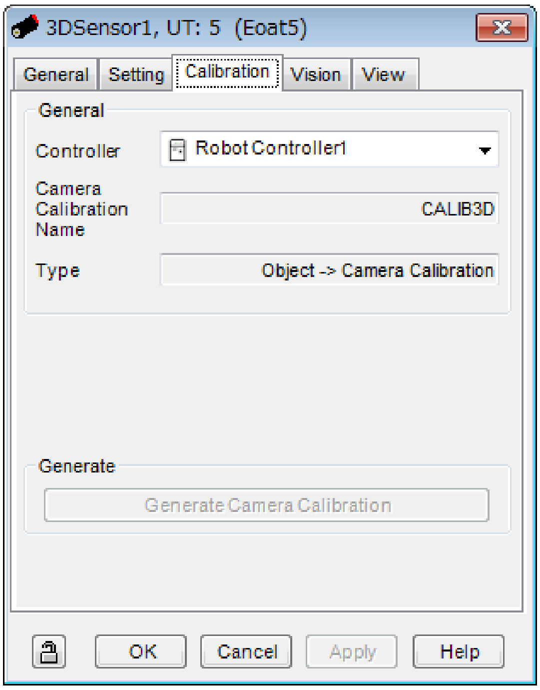


Fig. B.2(d) Automatically generating camera calibration data

B.3 TEACHING VISION PROCESSES

On ROBOGUIDE, teach the two types of vision processes below.

1 Vision processes for measuring three targets
2 Vision process for finding edge

Each of the methods is explained below.

B.3.1 Detecting Targets

Teach the vision process for measuring the base position of the part.

1 Open the "DeburrPathAutoGen" tab on the property page of the part, and press the "MoveTo" button for the first point, and the robot moves to the target of the first point. (Fig. B.3.1)

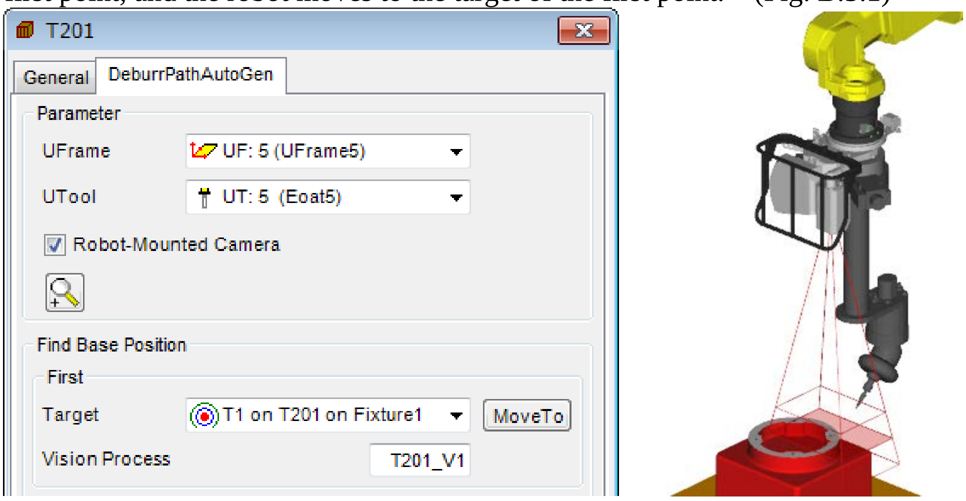


Fig. B.3.1 Moving to the found position

2 Open the "*i*RVision Setup Main - Camera Setup Tools" screen, with the operation described in B.2.2.
3 As described in Section 4.1, "TEACHING THE TARGET FINDING VISION PROCESS", create a new 3DL single-view vision process or a 2-D single-view vision process, and teach it.
4 Perform above operations for the second and third targets.

> ⚠ **CAUTION**
> If the contrast between the target and the surroundings is low, the target cannot be recognized in some cases.

B.3.2 Finding Edges

Teach the vision process for finding edges on the part.

1 Open the "Vision Setup" screen of *i*RVision.
2 Create a vision process for finding edges, and teach it. For details, see Section 4.2, "*i*RVision DEBURRING LINE OUTPUT VISION PROCESS".

B.4 SIMULATING DEBURRING OPERATIONS

After outputting a data file, perform camera calibration and teach vision processes. By executing the TP program loaded into the virtual robot, finding edge operation can be simulated.

1 From Programs of Cell Browser, select the main program for automatically generating a deburring path, DM_{Part Name}.TP. (Fig. B.4(a))

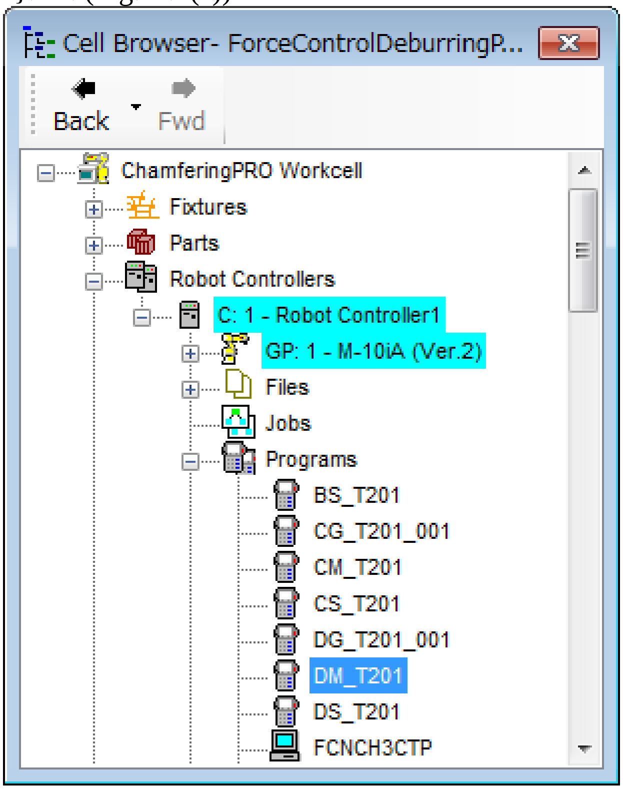


Fig. B.4(a) Selecting a TP program

2 Press the "Show/Hide Run Panel" button on the tool bar to display the Run Panel.
Set "Run-Time Refresh Rate (updates/sec)" to 30 or greater. If the refresh rate on the run panel is low, the vision-based detection may fail. (Fig. B.4(b))

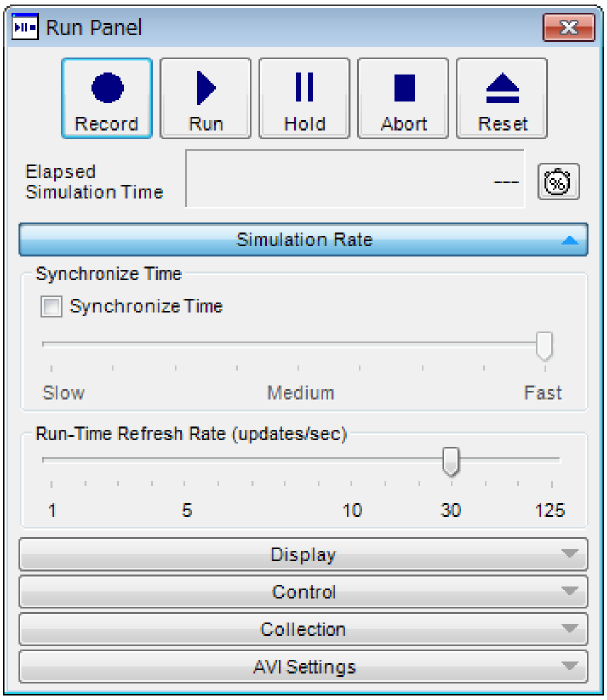


Fig. B.4(b) Run Panel

3 Press the "Run" button on the Run Panel, execute the selected TP program, and simulate the automatic generation of a deburring program by finding edges.
4 When the simulation is completed, the subprogram for deburring each edge with force control contouring operation, DU_{Part Name}_{Edge Index}.TP, is generated.
5 Select the main program for deburring with force control contouring operation, DS_{Part Name}.TP, and press the Run button on the Run Panel to simulate deburring.

> ⚠ **CAUTION**
> With ROBOGUIDE, force control cannot be simulated. On the actual machine, the Deburring Tool moves to touch the edges, so it moves along a path slightly apart from the teaching points of DU_{Part Name}_{Edge Index}.TP, but with ROBOGUIDE, the tool moves along the teaching points directly.

C SAMPLE TP PROGRAMS

This chapter describes sample TP programs automatically generated by ROBOGUIDE and the robot. It is assumed here that the part name is T201 and the edge name is FEATURE1.

C.1 TP PROGRAMS RELATED TO DEBURRING

C.1.1 DM_{Part Name}.TP

This is a main program for automatically generating a deburring path. It is generated by ROBOGUIDE.

- DM_T201.TP

```
1:  !ROBOGUIDE Auto-Generated TPP ;
2:  ! for FC Deburring Package, ;
3:  !T201 ;
4:    ;
5:  CALL BG_T201_T1 ;  }
6:  CALL BG_T201_T2 ;  } → Call BG_{Part Name}_T1.TP to BG_{Part Name}_T3.TP
7:  CALL BG_T201_T3 ;  }
8:    ;
9:  CALL DG_T201_001 ; } → Call DG_{Part Name}_{Edge Index}.TP
10: CALL DG_T201_002 ; }
```

C.1.2 BG_{Part Name}_T1.TP to BG_{Part Name}_T3.TP

They are subprograms for measuring the positions of three targets on the workpiece. They are called from DM_{Part Name}.TP and CM_{Part Name}.TP and generated by ROBOGUIDE.

For a robot-mounted camera

- BG_T201_T1.TP

```
1:  !ROBOGUIDE Auto-Generated TPP ;
2:  ! for FC Deburring Package, ;
3:  !T201 ;
4:  !Target 1 ;
5:    ;
6:  LBL[1] ;
7:  UFRAME_NUM=0 ;
8:  UTOOL_NUM=1 ;
9:    ;
10:J  P[1] 25% FINE    ;
11: VISION RUN_FIND 'T201_V1'    ;
12: VISION GET_OFFSET 'T201_V1' VR[5] JMP LBL[2] ;
13: CALL PTPGTPOS(5,1) ;
14:   ;
15: END ;
16: LBL[2] ;
17: UALM[5] ;
18: JMP LBL[1] ;
```

Convert the found position of target 1 (second argument) in VR[5] (first argument) into the world coordinate system, and store it in the KAREL variable.

For a fixed camera

- BG_T201_T1.TP

```
1:  !ROBOGUIDE Auto-Generated TPP ;
```

```
! for FC Deburring Package, ;
!T201 ;
!Target 1 ;
  ;
LBL[1] ;
UFRAME_NUM=0 ;
UTOOL_NUM=1 ;
  ;
VISION RUN_FIND 'T201_V1'      ;
VISION GET_OFFSET 'T201_V1' VR[5] JMP LBL[2] ;
CALL PTPGTPOS(5,1) ;
  ;
END ;
LBL[2] ;
UALM[5] ;
JMP LBL[1] ;
```

C.1.3 DG_{Part Name}_{Edge Index}.TP

This is a subprogram for detecting each edge and automatically generating a deburring path. It is called from DM_{Part Name}.TP. It is generated by ROBOGUIDE.

For a robot-mounted camera

- DG_T201_001.TP

```
!ROBOGUIDE Auto-Generated TPP ;
! for FC Deburring Package, ;
!T201, ;
!Feature1 ;
  ;
UFRAME_NUM=5 ;
UTOOL_NUM=1 ;
  ;
LBL[1] ;
CALL PTPINIT('T201','FEATURE1',’T201_DB’,51) ;
  ;
J  P[1] 25% FINE     ;
CALL LED_ON      ;
VISION RUN_FIND ’T201_DB’ ;
  ;
L  P[2] 500mm/sec FINE     ;
VISION RUN_FIND ’T201_DB’ ;
  ;
L  P[3] 500mm/sec FINE     ;
VISION RUN_FIND ’T201_DB’ ;
  ;
L  P[4] 500mm/sec FINE     ;
VISION RUN_FIND ’T201_DB’ ;
  ;
CALL LED_OFF      ;
CALL PTPDEBUR;  → Generate DU_{Part Name}_{Edge Index}.TP
  ;
IF R[51]<0,JMP LBL[2] ;
  ;
END ;
```

Set a workpiece name and an edge name, calculate the position of the user frame, and set it.
The first argument is a workpiece name.
The second argument is an edge name.
The third argument is a deburring line output vision process name
The fourth argument is the number of the register to which to output deburring path auto generation results.

Find an edge

```
LBL[2] ;
UALM[5] ;
JMP LBL[1] ;
```

For a fixed camera

- DG_T201_001.TP

```
!ROBOGUIDE Auto-Generated TPP ;
! for FC Deburring Package, ;
!T201, ;
!Feature1 ;
  ;
UFRAME_NUM=5 ;
UTOOL_NUM=1 ;
  ;
LBL[1] ;
CALL PTPINIT('T201','FEATURE1',’T201_DB’ ,51) ;
  ;
CALL LED_ON       ;
VISION RUN_FIND ‘T201_DB’       ;
  ;
CALL LED_OFF       ;
CALL PTPDEBUR       ;
  ;
IF R[51]<0,JMP LBL[2] ;
  ;
END ;
LBL[2] ;
UALM[5] ;
JMP LBL[1] ;
```

C.1.4 DS_{Part Name}.TP

This is a main program for performing deburring with force control contouring operation. It is generated by ROBOGUIDE.

- DS_T201.TP

```
!ROBOGUIDE Auto-Generated TPP ;
! for FC Deburring Package, ;
!T201 ;
  ;
CALL DU_T201_001       ; → Call DU_{Part Name}_{Edge Index}.TP
CALL DU_T201_002       ;
```

C.1.5 DU_{Part Name}_{Edge Index}.TP

This is a subprogram for performing deburring on each edge with force control contouring operation. It is called from DS_{Part Name}.TP. It is automatically generated from DG_{Part Name}_{Edge Index}.TP.

- DU_T201_001.TP

```
!ROBOGUIDE Auto-Generated TPP ;
! for FC Deburring Package, ;
!T201, ;
!Feature1 ;
```

```
  5:     ;
  6:    UFRAME_NUM=5 ;
  7:    UTOOL_NUM=5 ;
  8:     ;
  9:    CALL PTPINIT('T201','FEATURE1',' ',0) ;          ←Specify a part name and an edge name.
 10:    CALL PTPSETUF(5,1049.74,(-22.8),317.76,(-.1),(-1.32),(-14.308)) ;  ←Set a user frame.
 11:    PR[10,4]=0 ;
 12:    PR[10,5]=90 ;    ←Set "Push Dir. Offset Angle"
 13:    PR[10,6]=0 ;
 14:    CALL FCNCHCFR(1,10) ;  ←Change pushing direction in contouring schedule
 15:     ;
 16:J    P[1] 50% CNT100      ;                  ←Point above the contouring approach point
 17:L    P[2] 100mm/sec FINE      ;              ←Contouring approach point
 18:    FORCE CTRL[10:!ForDeburrOnly!] ErrorLBL[0] ;  ←Start contouring.
 19:L    P[3] 50mm/sec CNT100      ;            ←First edge point
 20:L    P[4] 50mm/sec CNT100      ;
 21:L    P[5] 50mm/sec CNT100      ;
 22:L    P[6] 50mm/sec CNT100      ;            ←Last edge point
 23:L    P[7] 50mm/sec FINE      ;              ←Leave point of contouring
 24:    FORCE CTRL[30:] ErrorLBL[0] ;           ←End contouring.
 25:L    P[8] 1000mm/sec CNT100      ;          ←Point above the leave point of contouring
```

If the “Non Stop When Gen. Fail” is enabled and the deburr path generation fails, the following TP program will be generated.

- For an open edge
  DU_T201_001.TP

```
  1:    ! Auto-Generated Deburring TPP ;
  2:    !    by FC Deburring Package ;
  3:    ! PART1 ;
  4:    ! FEATURE1 ;
  5:     ;
  6:    UFRAME_NUM=5 ;
  7:    UTOOL_NUM=5 ;
  8:     ;
  9:     ;
 10:    CALL PTPINIT('T201','FEATURE1',' ',0) ;          ←Specify a part name and an edge name.
 11:    CALL PTPSETUF(5,1049.74,(-22.8),317.76,(-.1),(-1.32),(-14.308)) ;  ←Set a user frame.
 12:     ;
 13:J    P[1] 50% CNT100      ;  ←Point above the first edge point
 14:L    P[2] 1000mm/sec CNT100    ;  ←Point above the leave point of contouring
```

- For a closed edge
  DU_T201_001.TP

```
  1:    ! Auto-Generated Deburring TPP ;
  2:    !    by FC Deburring Package ;
  3:    ! PART1 ;
  4:    ! FEATURE1 ;
  5:     ;
  6:    UFRAME_NUM=5 ;
  7:    UTOOL_NUM=5 ;
  8:     ;
  9:     ;
 10:    CALL PTPINIT('T201','FEATURE1',' ',0) ;          ←Specify a part name and an edge name.
```

```
11:   CALL PTPSETUF(5,1049.74,(-22.8),317.76,(-.1),(-1.32),(-14.308)) ;  ←Set a user frame.
12:    ;
13:J   P[1] 50% CNT100      ; ←Point above the first edge point
```

C.2 TP PROGRAMS RELATED TO UPDATING DATA FILES

C.2.1 CM_{Part Name}.TP

This is a main program for automatically generating a program for updating a data file. It is generated by ROBOGUIDE.

- CM_T201.TP

```
 1:   !ROBOGUIDE Auto-Generated TPP;
 2:   ! for FC Deburring Package,;
 3:   !T201;
 4:   ;
 5:   CALL BG_T201_T1;
 5:   CALL BG_T201_T2;
 5:   CALL BG_T201_T3;
 6:   ;
 7:   CALL CG_T201_001;           → Call CG_{Part Name}_{Edge Index}.TP
 8:   CALL CG_T201_002;
```

C.2.2 CG_{Part Name}_{Edge Index}.TP

This is a subprogram for automatically generating a program for finding each edge and updating a data file. It is called from CM_{Part Name}.TP. It is generated by ROBOGUIDE.

For a robot-mounted camera

- CG_T201_001.TP

```
 1:   !ROBOGUIDE Auto-Generated TPP;
 2:   ! for FC Deburring Package,;
 3:   !T201,;
 4:   !Feature1;
 5:   ;
 6:   ;
 7:   UFRAME_NUM=5;
 8:   UTOOL_NUM=5;
 9:   ;
10:   LBL[1];
11:   CALL PTPINIT('T201','FEATURE1','T201_DB',51) ;
12:    ;
13:J   P[1] 25% FINE      ;
14:   CALL LED_ON        ;
15:   VISION RUN_FIND 'T201_DB' ;  |
16:    ;                           |
17:L   P[2] 500mm/sec FINE      ;  |  Find an edge
18:   VISION RUN_FIND 'T201_DB' ;  |
19:    ;                           ↓
20:L   P[3] 500mm/sec FINE      ;
21:   VISION RUN_FIND 'T201_DB' ;
22:    ;
23:L   P[4] 500mm/sec FINE      ;
```

```
24:  VISION RUN_FIND 'T201_DB' ;
25:    ;
26:  CALL LED_OFF      ;
27:  CALL PTPCNTR      ; → Generate CT_{Part Name}_{Edge Index}.TP.
28:    ;
29:  IF R[51]<0,JMP LBL[2] ;
30:    ;
31:  END ;
32:  LBL[2] ;
33:  UALM[5] ;
34:  JMP LBL[1] ;
```

For a fixed camera

- CG_T201_001.TP

```
 1:  !ROBOGUIDE Auto-Generated TPP;
 2:  ! for FC Deburring Package,;
 3:  !T201,;
 4:  !Feature1;
 5:  ;
 6:  ;
 7:  UFRAME_NUM=5;
 8:  UTOOL_NUM=1;
 9:  ;
10:  LBL[1];
11:  CALL PTPINIT('T201','FEATURE1','T201_DB',51) ;
12:  ;
15:  VISION RUN_FIND 'T201_DB' ;
14:  ;
15:  CALL PTPCNTR;
16:  ;
17:  IF R[51]<0,JMP LBL[2] ;
18:    ;
19:  END ;
20:  LBL[2] ;
21:  UALM[5] ;
22:  JMP LBL[1] ;
```

C.2.3 CS_{Part Name}.TP

This is a main program for updating data files with force control contouring operation. It is generated by ROBOGUIDE.

- CS_T201.TP

```
1:  !ROBOGUIDE Auto-Generated TPP;
2:  ! for FC Deburring Package,;
3:  !T201;
4:  ;
5:  CALL CT_T201_001;        → Call CT_{Part Name}_{Edge Index}.TP
6:  CALL CT_T201_002;
```

C.2.4 CT_{Part Name}_{Edge Index}.TP

This is a subprogram for updating the data files for each edge with force control contouring operation. It is called from CS_{Part Name}.TP. It is automatically generated from CG_{Part Name}_{Edge Index}.TP.

- CT_T201_001.TP

```
 1:   UFRAME_NUM=5 ;
 2:   UTOOL_NUM=5 ;
 3:   CALL PTPINIT('T201','FEATURE1',' ',0) ;          ←Specify a part name and an edge name.
 4:   CALL PTPSETUF(5,1049.74,(-22.8),317.76,(-.1),(-1.32),(-14.308)) ; ←Set a user frame.
 5:J   P[1] 25% CNT100     ;              ←Point above the contouring approach point
 6:L   P[2] 100mm/sec FINE     ;          ←Contouring approach point
 7:   RUN   CTRMONIT   ;                  ←Start position recording
 8:   FORCE CTRL[10:!ForDeburrOnly!] ErrorLBL[0] ;      ←Start contouring.
 9:L   P[3] 50mm/sec CNT100    ;          ←First edge point
10:L   P[4] 50mm/sec CNT100    ;
11:L   P[5] 50mm/sec CNT100    ;
12:L   P[6] 50mm/sec CNT100    ;          ←Last edge point
13:L   P[7] 50mm/sec FINE    ;            ←Leave point of contouring
14:   FORCE CTRL[30:] ErrorLBL[0] ;       ←End contouring.
15:   CALL PTPEND;                        ←End position recording, and update the data file.
16:L   P[8] 500mm/sec CNT100    ;         ←Point above the leave point of contouring
```

C.2.5 CTRMONIT.TP

This is a subprogram for recording the robot position. It is called from CT_{Part Name}.TP. It is automatically generated from CG_{Part Name}_{Edge Index}.TP.

- CTRMONIT

```
 1:   CALL PTPMONIT;          ←Record the position.
```

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REVISION RECORD

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