HUCENROTIA LAB

O2O TEACHING SYSTEM

OPERATION MANUAL

0 Table of Contents

1 System overview

The offline-to-online (O2O) is a robotic teaching method that combine the online teaching and offline teaching method. This method utilizes an offline software to generate the trajectory to be used as a reference trajectory. Then, the reference trajectory is combined with the online method to improve the performance and accuracy of the offline trajectory to perform the tasks. The online teaching method implements a haptic teleoperation system to assist the operator to control the robot arm. Thus, the operator does not need to directly interact with the robot, for example in the lead-through programming. By using teleoperation, the operator can teleoperate the robot and control the movement from distance. The O2O system comprises of three main components: (1) **haptic teleoperation device**, (2) **offline robot simulator**, and (3) **robot hardware**. Figure 1.1 shows the overview of the O2O system.

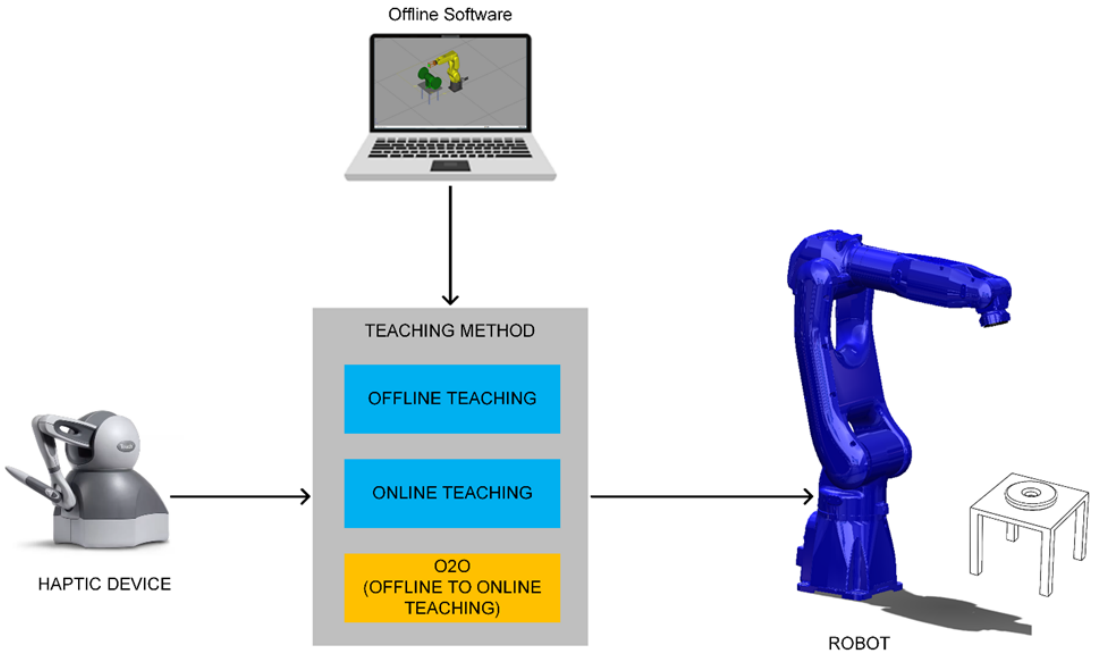


Figure 1.1 System Overview

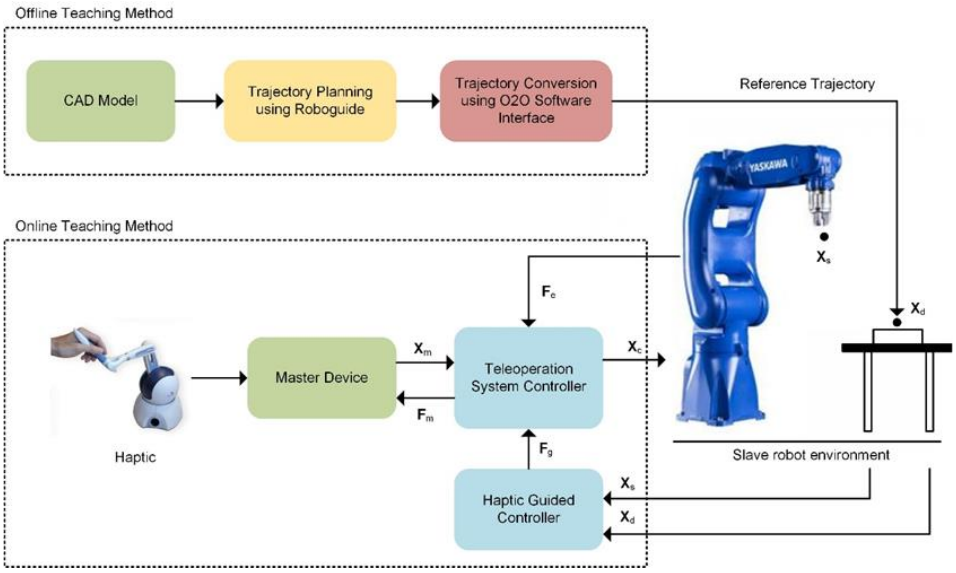


Figure 1.2 System Diagram

For the current version, the O2O system is integrated with the ROBOGUIDE software by FANUC to assist the OFFLINE teaching process. By using ROBOGUIDE the operator can create a trajectory planning by utilizing the 3D CAD model of the workpiece. Then, it can also simulate the motion of the robot to execute the generated trajectory, and it is useful to evaluate the performance of the trajectory before implementing it in the real system.

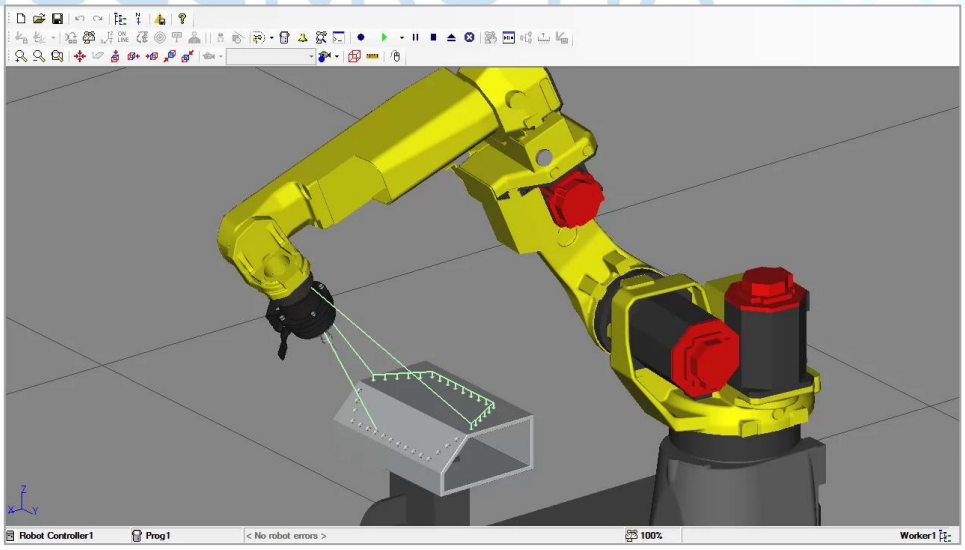


Figure 1.3 Offline trajectory planning by using ROBOGUIDE

2 Installation Procedure

This section describes the installation procedure of the O2O teaching system. The installation comprises of two steps, installation of robot hardware and the haptic teleoperation device. Figure 2.1 shows the hardware system of O2O.

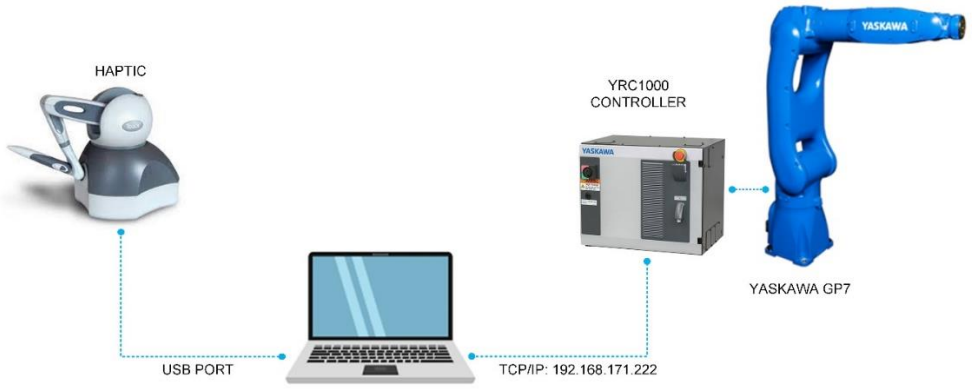


Figure 2.1 Hardware Connection

2.1 System Requirement

The haptic device requires certain hardware and software components to be able to function properly. This section describes the minimum requirements for operating the haptic device.

Operating System	64-bit Windows 8.1, and 10
Processor	Intel i5 / i7, 5th Generation or greater CPU, Minimum 2.5 GHz frequency
RAM	4 GB
Graphics Card	Minimum 256 MB VRAM (Install the latest drivers)
Disk Space	512 MB
Display Resolution	1280 x 800 (Minimum)
Interface	USB 2.0 / 3.0 port or USB Hub that supports USB 2.0/ 3.0. (Use only USB A to B cable provided by 3D Systems).
OpenHaptics ® SDK Compatibility	Yes

2.2 Robot Connection

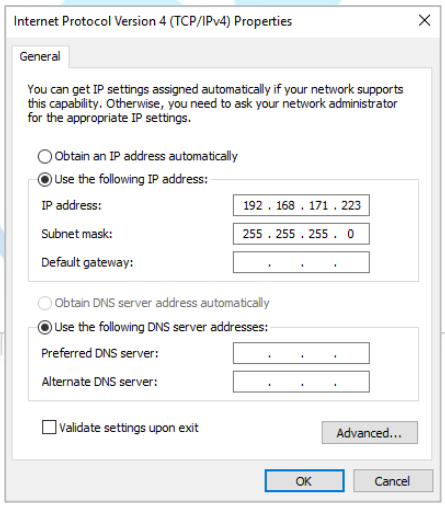
The YRC1000 is installed with a LAN port (RJ45 connector) that used as the data communication through the Ethernet. To connect with the O2O software interface, the operation mode of the YRC1000 need to be set in remote mode.

1) TURN ON the YRC1000 controller and then switch the operation mode into REMOTE MODE.

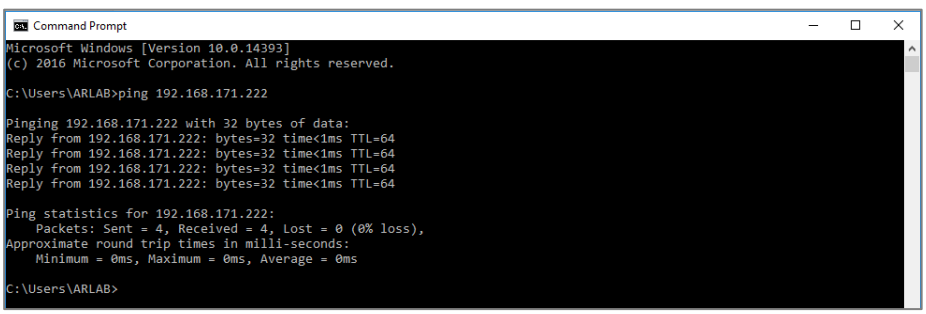
2) Connect the PC and YRC1000 controller using LAN cable.
3) Set the IP address on the local PC/Laptop with the following configuration. The IP address should be adjusted in accordance with the setting of IP address in robot teach pendant. In this example, the configuration of the IP address in the robot is 192.168.171.222, so the configuration of IP address in the PC/laptop is

   IP Address : **192.168.171.223**

   Subnet mask : **255.255.255.0**



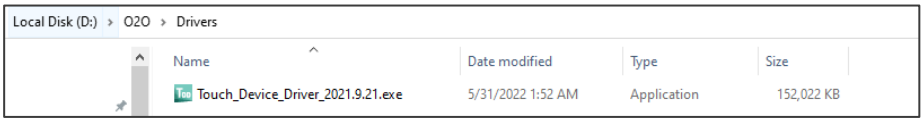
4) Open Windows Command Prompt and then type: **ping 192.168.171.222**
5) If the connection success, it will send the reply as follows:



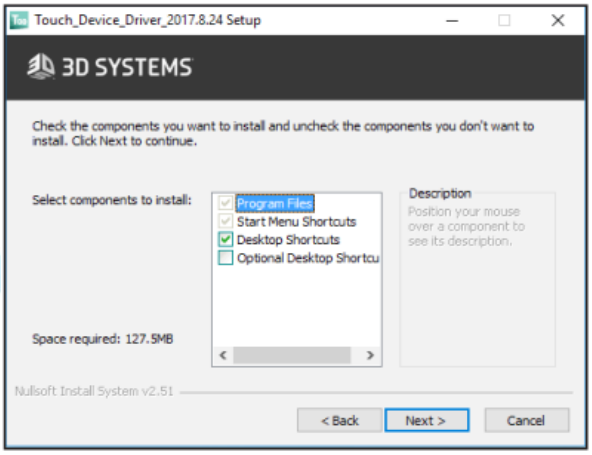
2.3 Haptic Device Connection

The 3DS Touch X Haptic device uses a USB connection to communicate with the PC. The installation of the driver is described as follows:

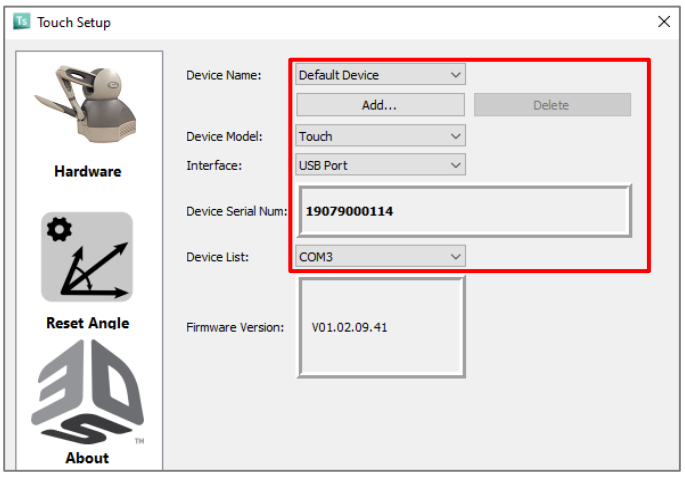
1) Install the haptic driver. In the installation CD and driver, open **O2O folder → Driver → Touch_Device_Driver_2021.9.21.exe**.



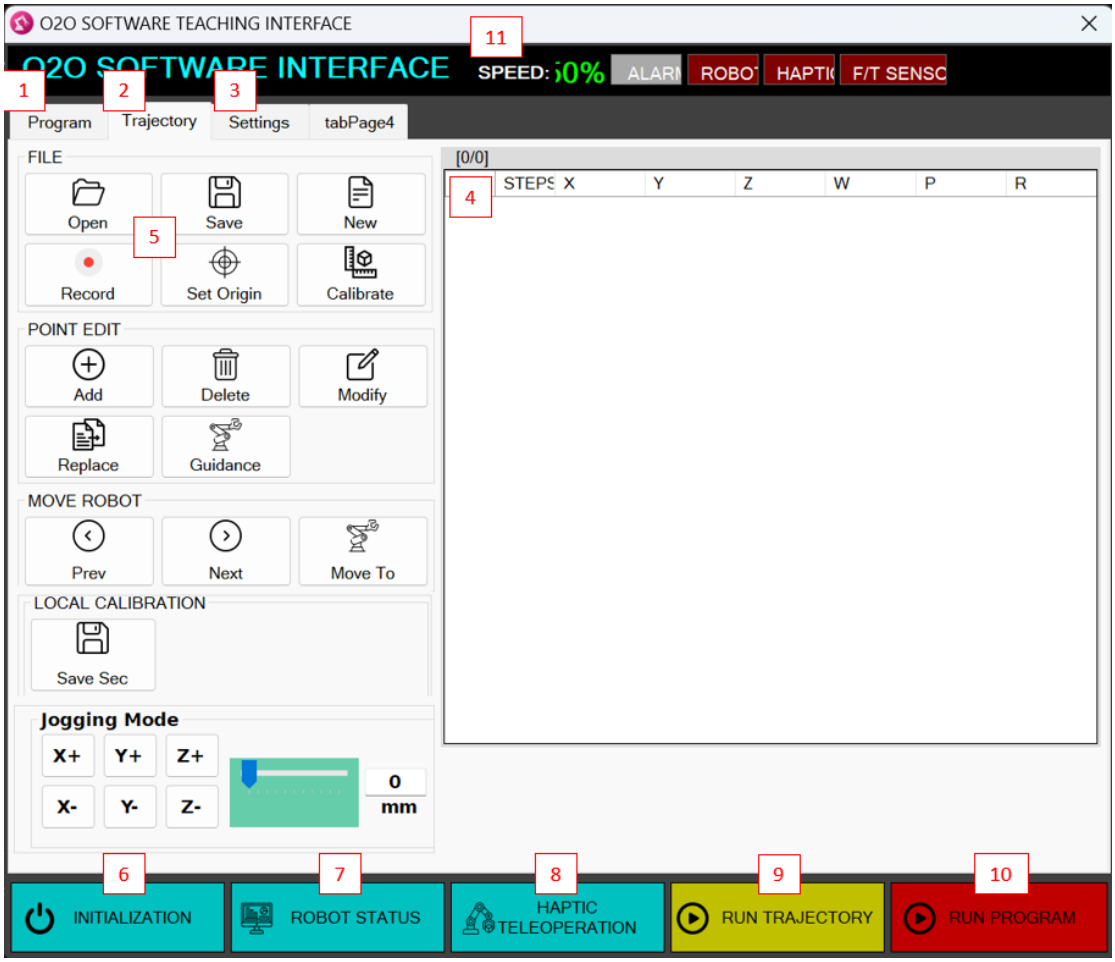
2) Follow the Install Wizard to start the installation of the Touch Device Driver.



3) In the Select components to install, be sure to check box, “Desktop Shortcut” is selected. This will create desktop shortcuts for the Touch Smart Setup Application.
4) Wait until the installation is finish.
5) To ensure the haptic device is detected, open **Touch Smart Setup** program. If the haptic is detected, the software will show the haptic device name and the port number.



3 O2O Software Interface Overview

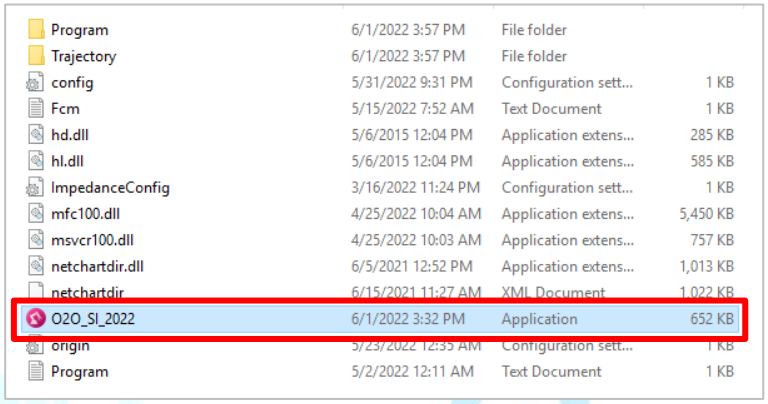


(1) Program editor : Create a sequence program
(2) Trajectory editor : Menu to modify the trajectory
(3) Program settings : Menu to configure robot and program setting
(4) Table editor : Display the trajectory data
(5) Control buttons : Buttons to control and navigate the program
(6) Button initialization : Click this button to connect to the hardware and devices
(7) Robot status button : Display the robot position and data
(8) Haptic teleoperation button : Start haptic teleoperation control
(9) Run trajectory : Execute the trajectory
(10) Run Program : Execute the main program
(11) Indicator : Show the indicator of the hardware status and connection

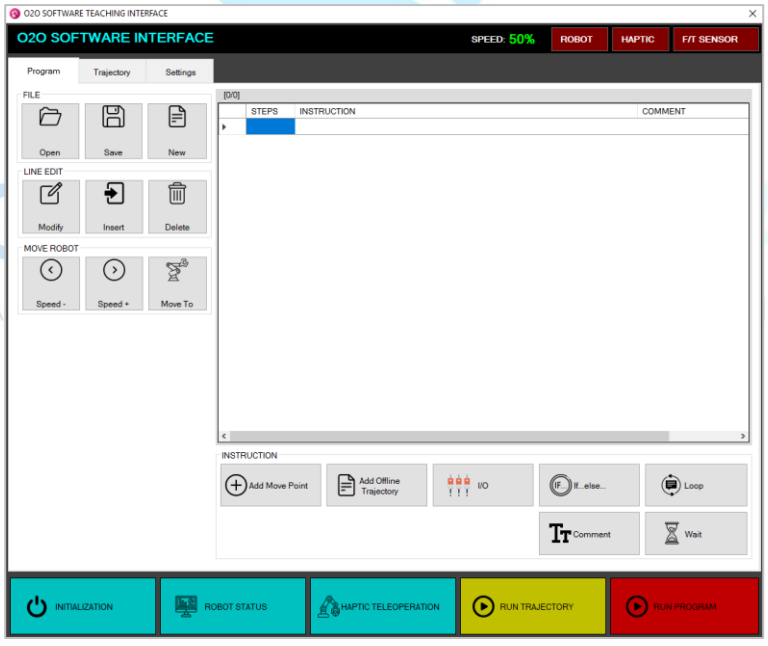
4 O2O Software Interface Operation

4.1 Program Initialization

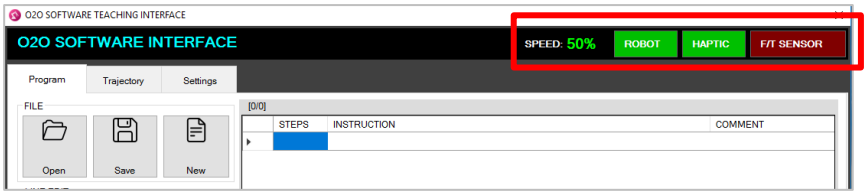
1. Open the O2O software interface folder and make sure it has the following files and folders.



2. Open the **O2O_SI_2022.exe.** If the setup is success it will show the main page of the interface.



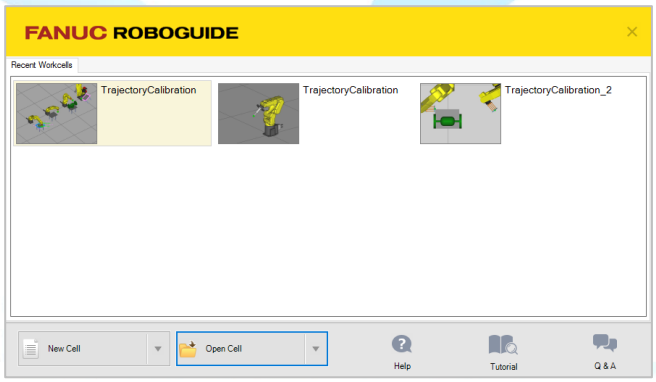
3. Click the INITIALIZATION button to connect the robot and haptic device.
4. If the connection is success, the indicator light of the robot and haptic will turn to green.



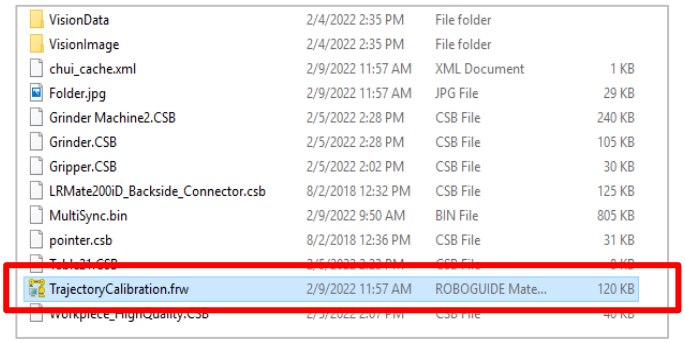
4.1 Offline Trajectory Recording

The O2O software interface utilizes the ROBOGUIDE software to perform the offline trajectory teaching. To record the trajectory from ROBOGUIDE, the complete robot work cell needs to design in ROBOGUIDE. However, this section only explains the trajectory recording by using O2O software interface. Please refer to ROBOGUIDE manual section to get more detail about the operation of the software.

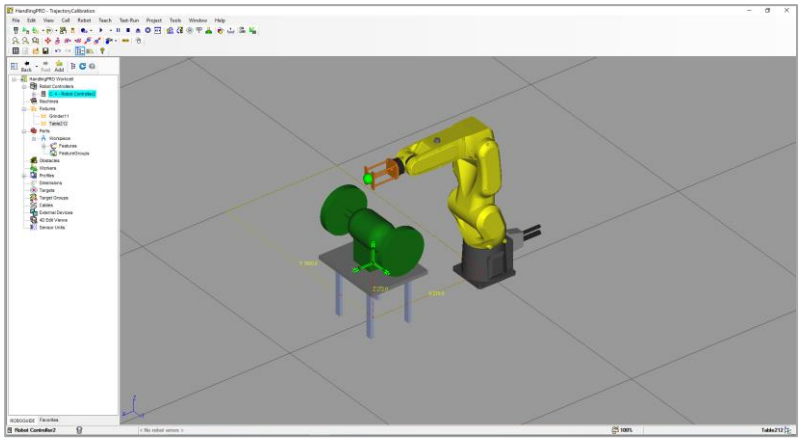
1) Open ROBOGUIDE then click OPEN CELL.



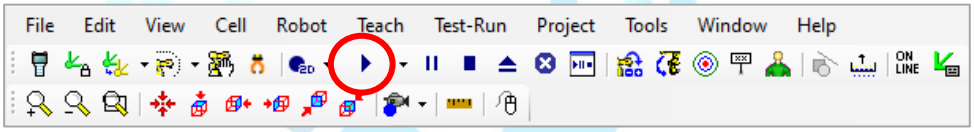
2) The example of ROBOGUIDE project for SSD polishing is attached in the CD driver. Go to O2O folder → ROBOGUIDE Example → Trajectory Calibration → TrajectoryCalibration.frw



3) If the program is successfully loaded, the SSD polishing cell main window will appear.

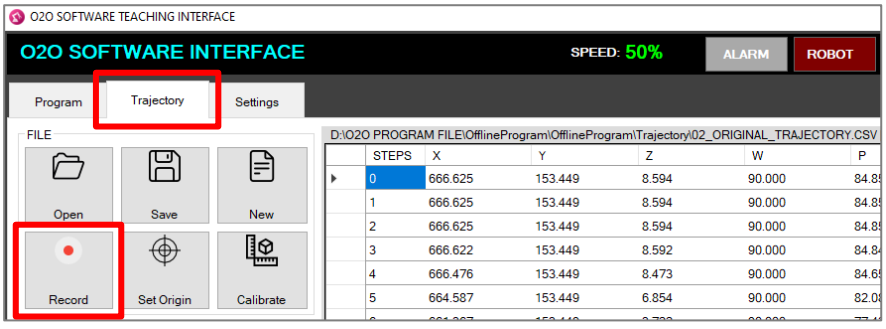


4) To run and test the program, click the Cycle Start button.

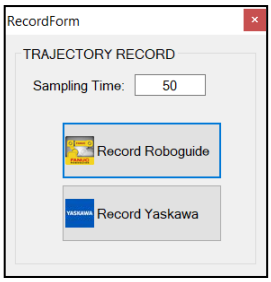


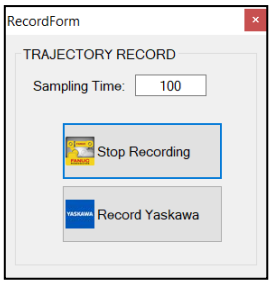
5) Up to this step, we can evaluate the performance of the offline teaching based on the simulation result. If the result is OK, we can use the O2O software to record the trajectory.

6) Open the O2O Software Interface. Select TRAJECTORY tab and the click RECORD button.



7) Then, the RECORD dialog will appear.





8) Specify the sampling time for the trajectory recording. The default value of the sampling time is 100ms.

9) The sampling time can be adjusted from 50 – 500 ms.

10) To record from ROBOGUIDE, select the RECORD ROBOGUIDE button.

11) Wait until the recording process is finish.

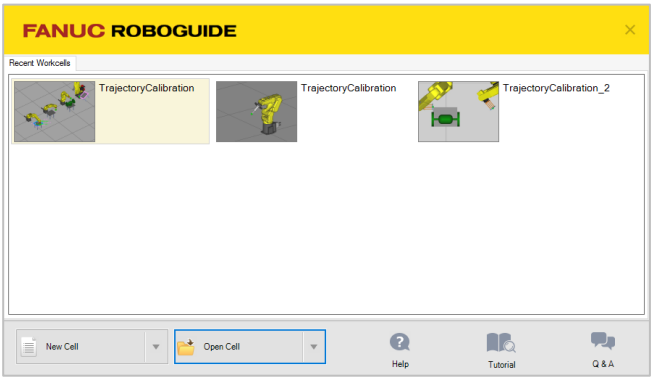
12) To stop the recording process, press the STOP RECORDING button.

13) The results of the recorded trajectory will appear in the TRAJECTORY EDITOR menu.

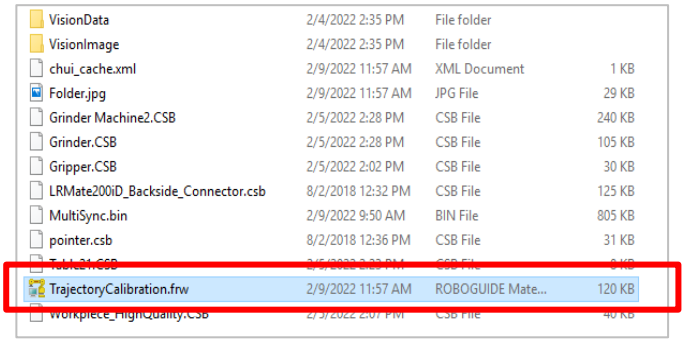
4.2 YASKAWA Motion Recording

The O2O software interface utilizes the ROBOGUIDE software to perform the offline trajectory teaching. To record the trajectory from ROBOGUIDE, the complete robot work cell needs to design in ROBOGUIDE. However, this section only explains the trajectory recording by using O2O software interface. Please refer to ROBOGUIDE manual section to get more detail about the operation of the software.

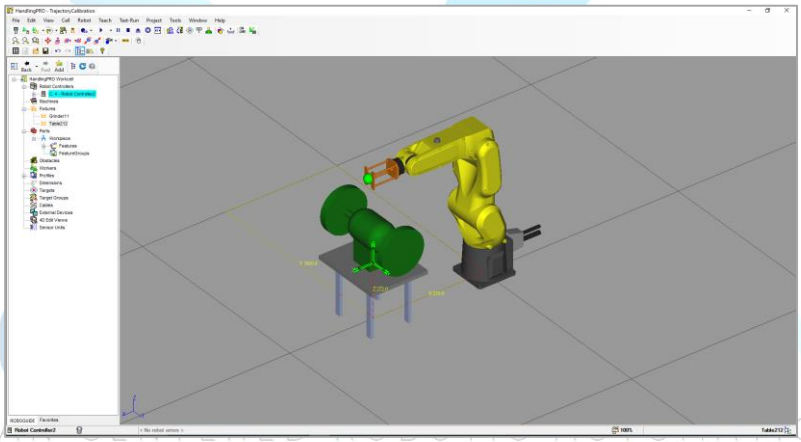
1) Open ROBOGUIDE then click OPEN CELL.



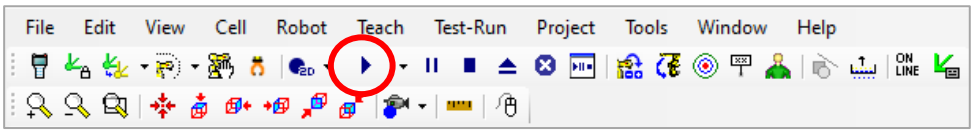
2) The example of ROBOGUIDE project for SSD polishing is attached in the CD driver. Go to O2O folder → ROBOGUIDE Example → Trajectory Calibration → TrajectoryCalibration.frw



3) If the program is successfully loaded, the SSD polishing cell main window will appear.

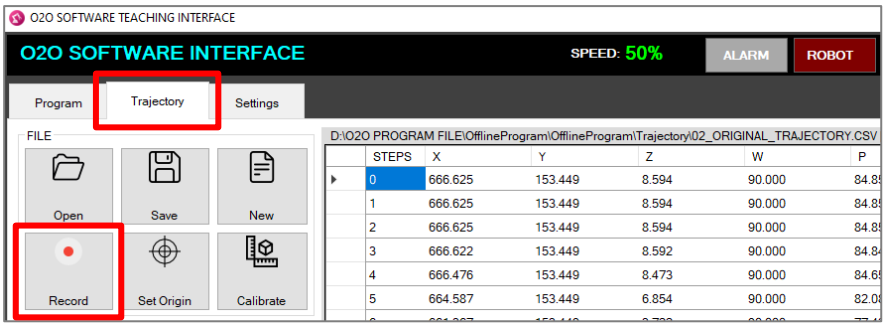


4) To run and test the program, click the Cycle Start button.

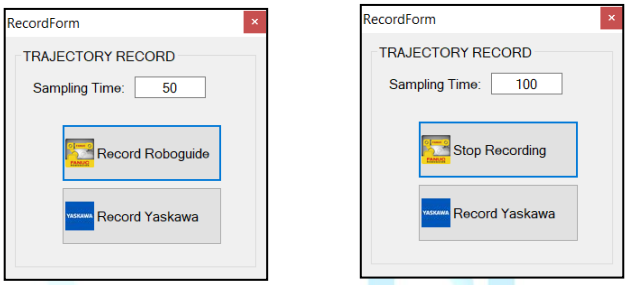


5) Up to this step, we can evaluate the performance of the offline teaching based on the simulation result. If the result is OK, we can use the O2O software to record the trajectory.

6) Open the O2O Software Interface. Select TRAJECTORY tab and the click RECORD button.



7) Then, the RECORD dialog will appear.



8) Specify the sampling time for the trajectory recording. The default value of the sampling time is 100ms.

9) The sampling time can be adjusted from 50 – 500 ms.

10) To record from ROBOGUIDE, select the RECORD ROBOGUIDE button.

11) Wait until the recording process is finish.

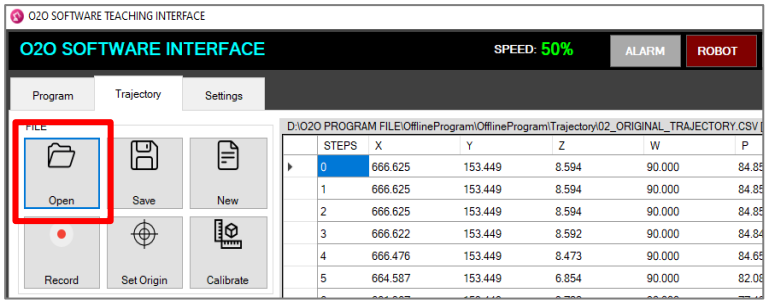
12) To stop the recording process, press the STOP RECORDING button.

13) The results of the recorded trajectory will appear in the TRAJECTORY EDITOR menu.

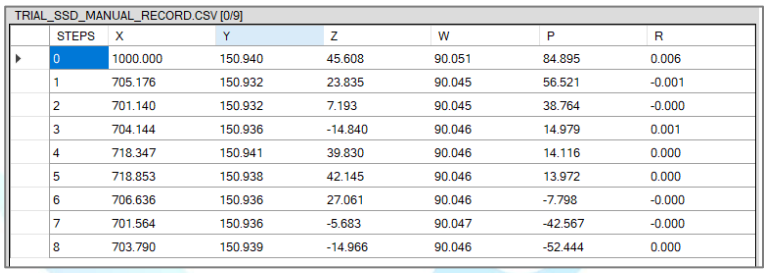
4.3 Trajectory Editing

The trajectory editing function is used to modify the offline trajectory generated from the offline teaching process. The adjustment and modification are assisted by using a haptic teleoperation device. The steps of the trajectory editing are described as follows:

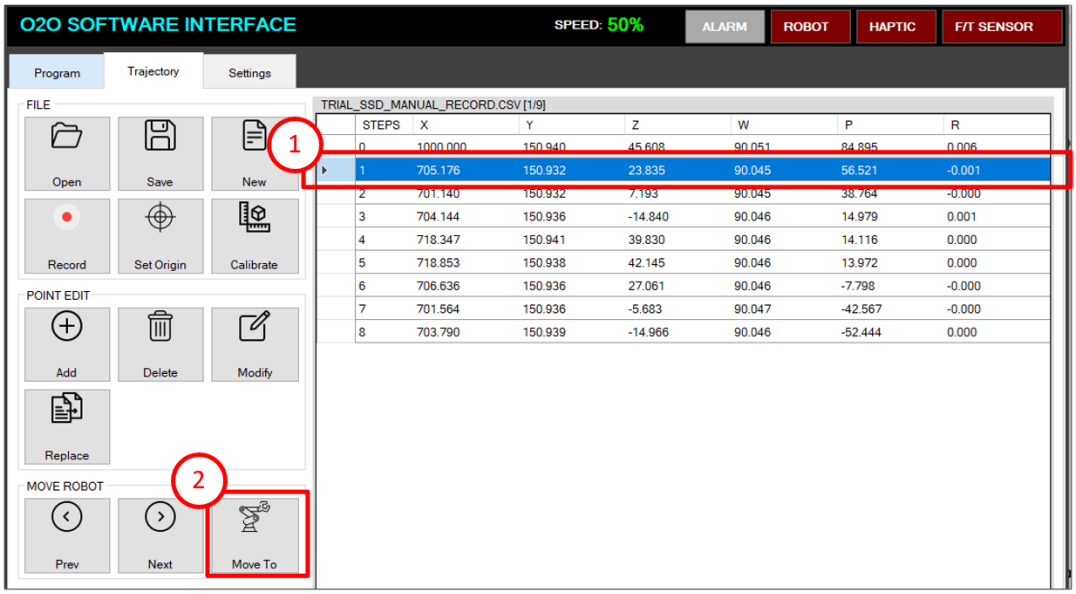
1) Import the offline trajectory file into the trajectory editor. Click OPEN button and then select the file to be modified.



2) Then, the trajectory data will appear in the table editor. The data consist of 6 data of position and orientation of waypoints (X, Y, Z, Rx, Ry, Rz).



3) To move the robot to the desired position, select the waypoint number and then click MOVE button.



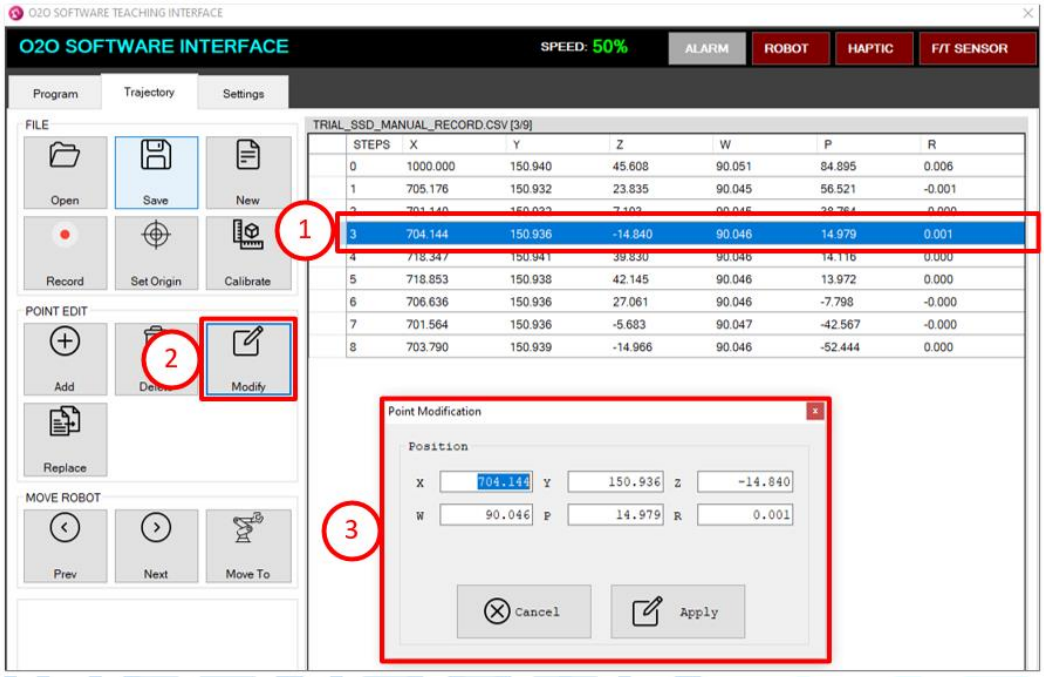
4) Then the robot will move to the desired position.

5) Repeat STEP 3 to test another trajectory point (waypoints).

6) If the position of the waypoints is not good, it can be modified by using two methods: (1) direct entry and (2) teleoperation.

Method 1: Direct Entry

7) In direct entry method, select the number of the waypoints in the table, then click MODIFY button. The POINT MODIFICATION dialog will appear.



8) Change the position value (X, Y, Z, W, P, R) in accordance with the desired position. Then click APPLY button.

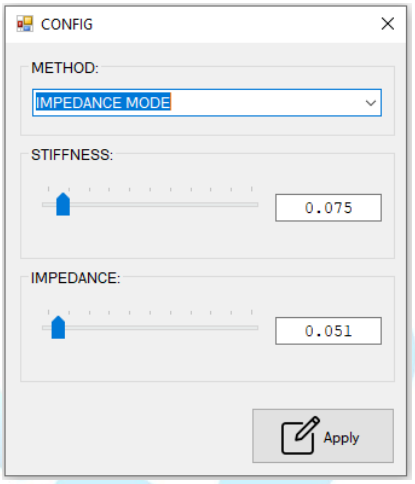
9) Then in the editor table, the value of the position will change as the given position.

Method 2: Teleoperation

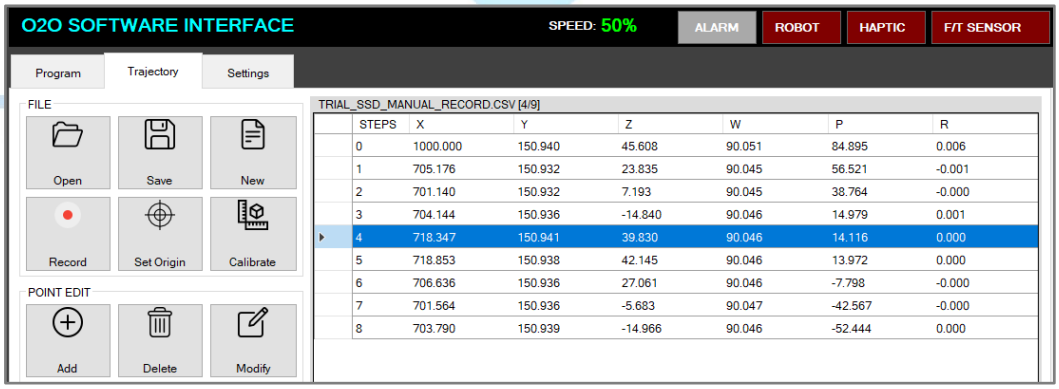
10) To modify the position by using teleoperation method, firstly, adjust the haptic operation mode.

11) Select SETTINGS → HAPTIC SETTING. Then the HAPTIC SETTING dialog will appear.

12) In the METHOD menu, select the IMPEDANCE MODE, then click APPLY.



13) Go to TRAJECTORY EDITOR and then select the number of STEP to be modified.



STEPS	X	Y	Z	W	P	R
0	1000.000	150.940	45.608	90.051	84.895	0.006
1	705.176	150.932	23.835	90.045	56.521	-0.001
2	701.140	150.932	7.193	90.045	38.764	-0.000
3	704.144	150.936	-14.840	90.046	14.979	0.001
4	718.347	150.941	39.830	90.046	14.116	0.000
5	718.853	150.938	42.145	90.046	13.972	0.000
6	706.636	150.936	27.061	90.046	-7.798	-0.000
7	701.564	150.936	-5.683	90.047	-42.567	-0.000
8	703.790	150.939	-14.966	90.046	-52.444	0.000

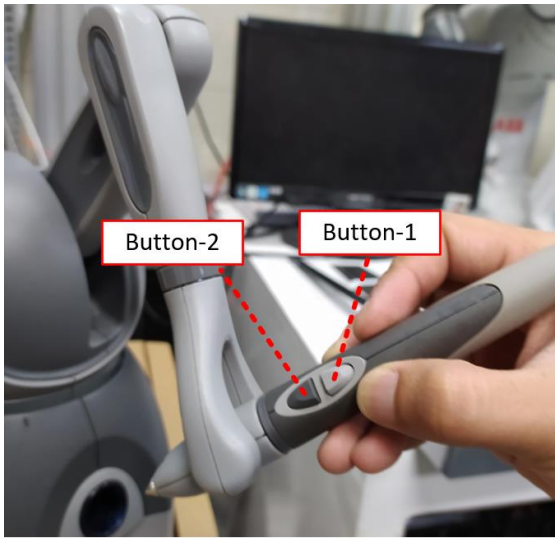
14) Click MOVE button to move the robot to the selected position.

15) Up to this step we will start to use haptic to control the movement of the robot arm.

Before connecting the haptic, please hold the haptic stylus tightly.

16) Click HAPTIC TELEOPERATION button to start the teleoperation control. Then the indicator button will turn to green.

17) To turn ON the haptic control, press BUTTON 1 in the haptic stylus as shown in the following image.



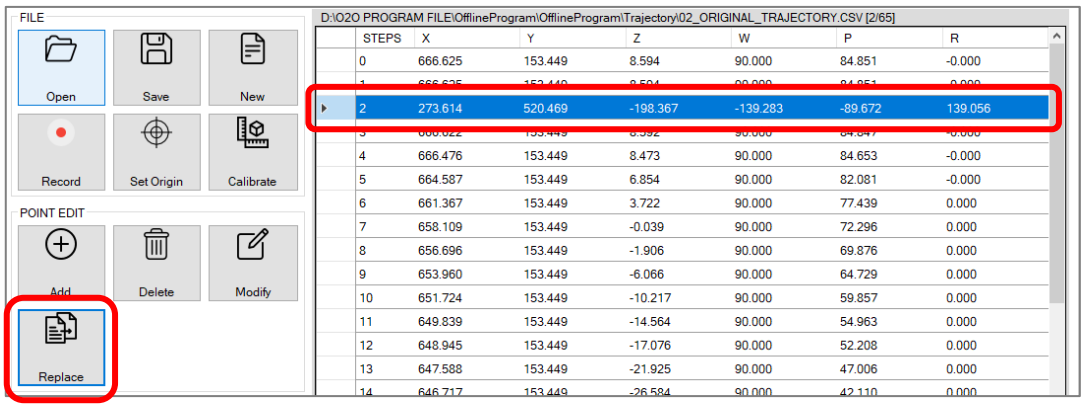
18) If the teleoperation control is ON, the system will give force feedback and the user can feel the feedback when holding the haptic stylus.

19) The feedback force works as a guidance that enable the user to move the robot around the selected point.

20) Adjust the position of the robot by using haptic so that the robot can achieve a better position.

21) After the robot reach the target, disconnect the haptic connection by pressing BUTTON 1 in the haptic stylus. Then put the stylus in the haptic holder.

22) To save the new robot position, click the REPLACE button in TRAJECTORY EDITOR. So, the program will replace the previous position with the new position.



23) Repeat steps 15 – 22 to modify another waypoint of the offline trajectory.

Add & Delete a Point

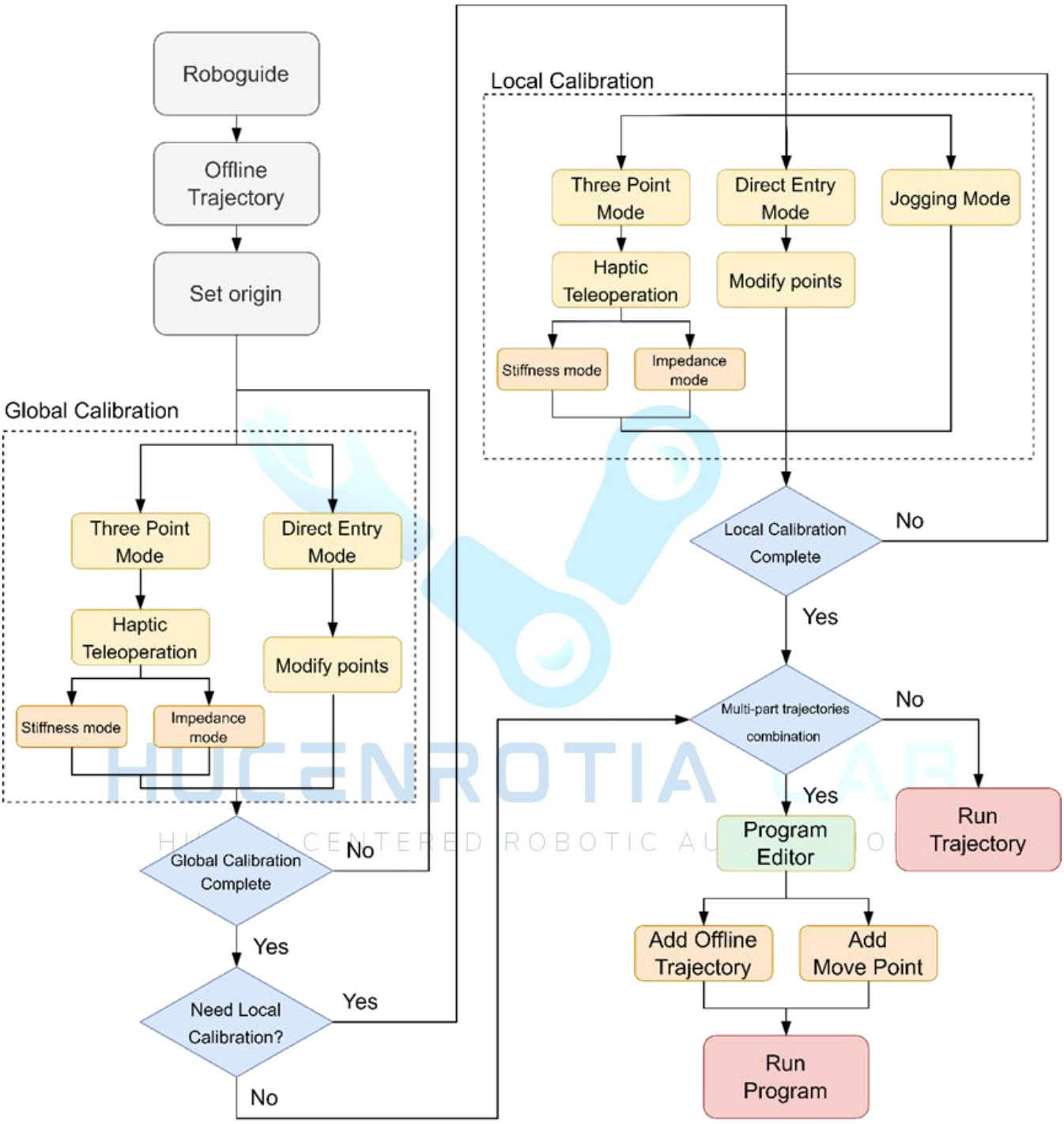
24) To insert a new point in the existing trajectory, click the STEP number of the desired position, then click ADD button.

25) To a new line will inserted in the TRAJECTORY EDITOR.

26) Click DELETE button to remove the selected point.

4.4 Sequence Program Editing

5. O2O System Flow



6. Trajectory Calibration

6.1 Global Calibration

6.2 Local Calibration

6.3 Direct Entry Mode

6.4 Three-point Mode

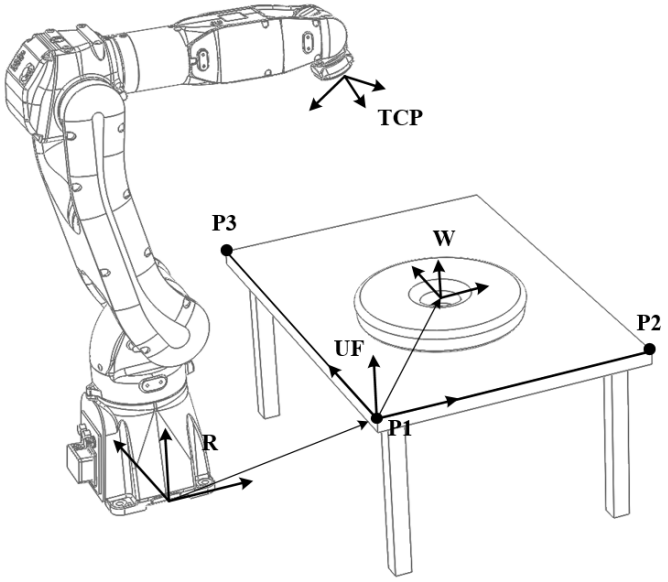
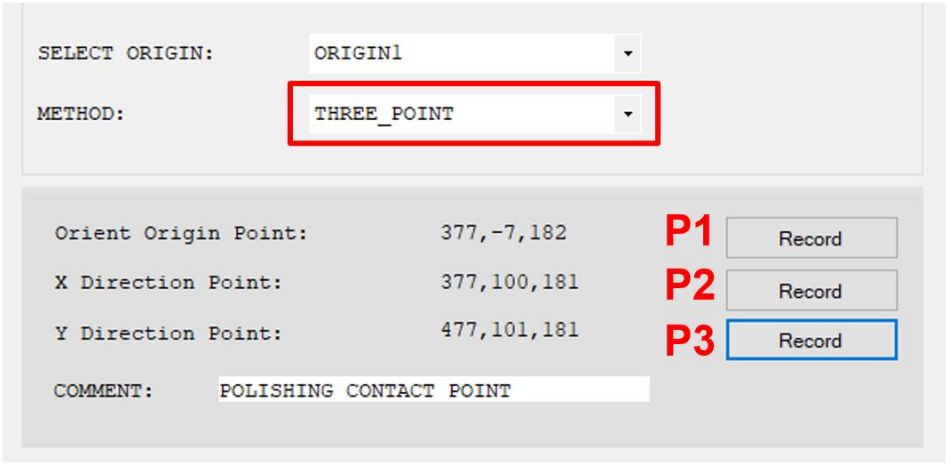


Figure 5.1 Three-point calibration method

1) To calibrate the trajectory using three-point method, select the METHOD as THREE-POINT method.



2) Move the robot to teach the three calibration points as shown in Figure 5.2.

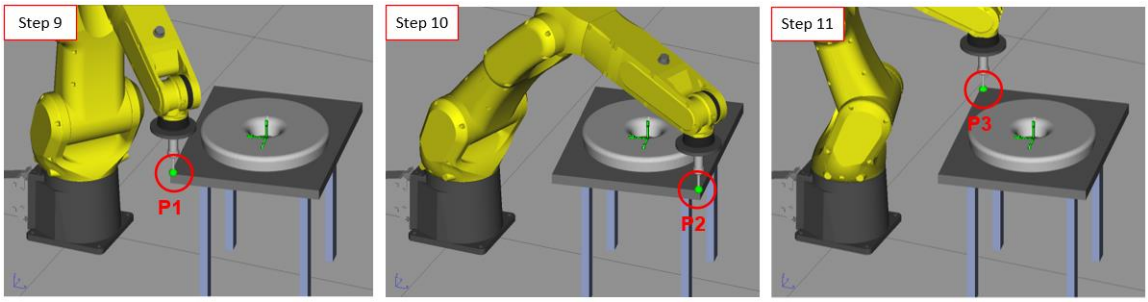
3) Move the robot to P1 (origin point) and then click RECORD button.

4) Then move the robot to P2 (X direction point) and then click RECORD button.

5) Then move the robot to P3 (Y direction) and click RECORD button.

6) The user can specify the description of the origin point in the COMMENT textbox.

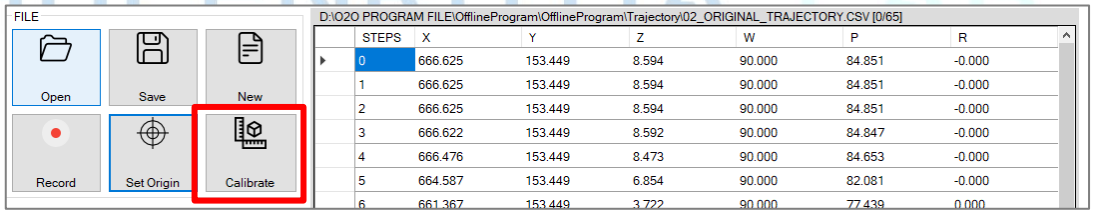
7) Finally click APPLY button to save the configuration.



Apply Calibration

8) After set the origin position, the final step of the calibration is to apply the calibration to the offline trajectory.

9) In TRAJECTORY EDITOR, click CALIBRATE button.



STEPS	X	Y	Z	W	P	R
0	666.625	153.449	8.594	90.000	84.851	-0.000
1	666.625	153.449	8.594	90.000	84.851	-0.000
2	666.625	153.449	8.594	90.000	84.851	-0.000
3	666.622	153.449	8.592	90.000	84.847	-0.000
4	666.476	153.449	8.473	90.000	84.653	-0.000
5	664.587	153.449	6.854	90.000	82.081	-0.000
6	661.367	153.449	3.722	90.000	77.439	0.000

10) If you want to save the current trajectory, click SAVE.

11) Finally, the offline trajectory data will be updated with the new calibrated trajectory.

10.