iNexBot

Human-Robot Collaboration

Catalogue

Human-Robot Collaboration

This chapter mainly introduces the role of dynamics and how to use it.

Because of the complex nonlinearity, time-varying uncertainty, and strong coupling of the robot (especially during high speed motion), to enable the robot to move at the desired speed and acceleration, the servo motor of each joint of the robot must have sufficient force and torque to drive the linkages and joints of the robot, otherwise the linkages will affect the robot's positioning and trajectory tracking accuracy due to slow movement, so it is necessary to establish feedforward torque control based on a dynamics model, so that the feedforward compensation torque can be quickly calculated in real time.

Human-Robot Collaboration (HRC) refers to work scenarios in which humans and automated robots share a workspace and work simultaneously.

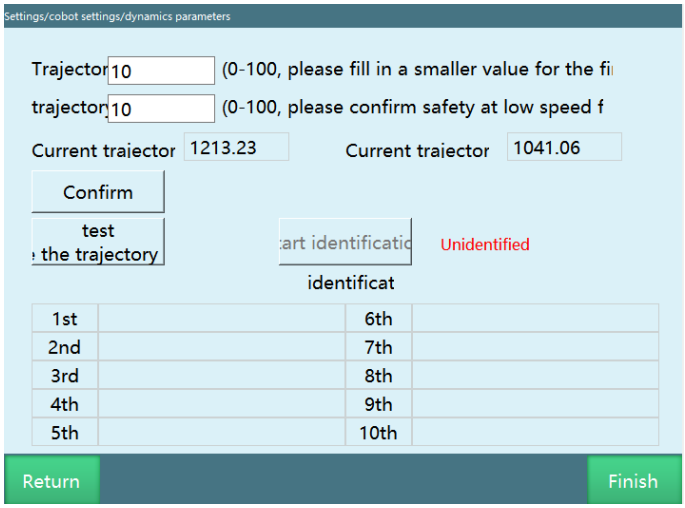
Dynamics parameters

Before using the mechanical functions, you first need to set up the dynamics parameters so that the controller builds a dynamics model of the robot.

Enter **"Settings/Human-robot collaboration/Dynamics parameters"** to set the dynamics parameters.

Identification

Before entering the identification interface, you need to read the notes related to identification carefully. When the robot performs identification, it is best to increase the range and speed from small to large. If there are external factors that prevent the robot from reaching the trajectory range of 100, you can properly adjust the positive and negative limits in the joint parameters. By running a test to make sure that there are no obstacles around the robot and that it can run at a speed of 100, you can start identifying. During the identification process, it is best not to operate the teach pendant, and people need to stay away from the robot. If you need to pause the operation, you can stop the robot by clicking on the stop button on the teach pendant or by pressing the emergency stop button.



Parameter description

Trajectory range: The maximum and minimum motion range of the robot is calculated based on the trajectory range.

Trajectory speed: The speed of the robot while it is running, independent of the global speed.

Current trajectory Z maximum value/Current trajectory Z minimum value: The range of the current trajectory in Z-axis direction.

Identification error: After identification, six parameters will appear representing the error of each of the six axes (The smaller the value, the smaller the error, but the value cannot be zero).

Read before use

Warnings

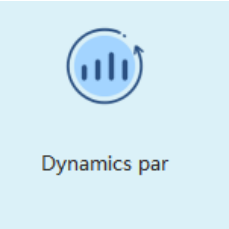
- At present, this identification method is only applicable to the identification of the robot body dynamics parameters of a 6-axis robot under no load.
- The dynamics parameters identified by this identification method are

independent of the hand-filled dynamics parameters.

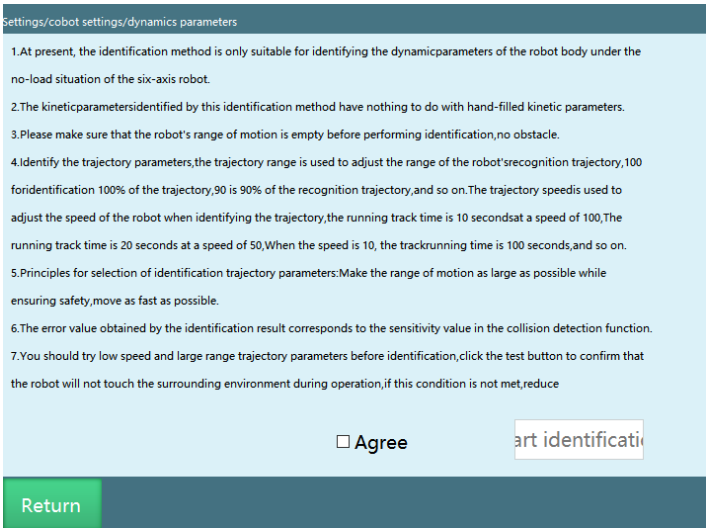
- Make sure that the robot's range of motion is clear and free of obstacles before performing identification.
- In the trajectory identification parameters, the trajectory range is used to adjust the trajectory identification range of the robot, 100 is to identify 100% of the trajectory, 90 is to identify 90% of the trajectory, and so on.The trajectory speed is used to adjust the speed of the robot when it performs the trajectory identification. The trajectory running time is 10 seconds when the speed is 100, 20 seconds when the speed is 50, 100 seconds when the speed is 10, and so on.
- The selection principle of trajectory identification parameters: Make the range of motion as large as possible and the speed as fast as possible while ensuring safety.
- The error value obtained from the identification result corresponds to the sensitivity value in the collision detection function.
- Before identification, you should try the low speed and wide range of trajectory parameters, and click the "Test" button to confirm that the robot will not touch the surrounding environment during operation. If the condition is not met, reduce the trajectory range parameter, run at low speed again to ensure that it will not touch the surrounding environment, and then set the trajectory speed to 100, and click the "Start identification" button to perform robot parameter identification.
- When testing trajectory safety, the robot will run two trajectories. Please do not approach the robot until the test is completed.
- The robot will run two trajectories when identifying the trajectory, please run 10 times, you must not approach the robot during this time, because the robot may start at any time.
- The identification work is executed ten times, including the process of running trajectory, obtaining data, analyzing data, calculating dynamics parameters, etc. The error value is displayed on the interface after each execution, and the whole process will last about 30 minutes, please do not do any operation during this period to avoid affecting the identification work.

Operation steps

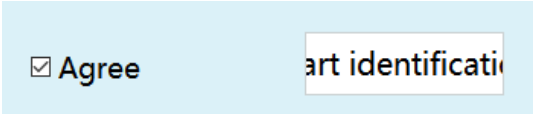
1. Adjust the robot joint parameters-joint limits to ensure that all robot movements are within safe limits and that all of the following trajectories will move within the limits.
2. **Move the robot to the zero position.**
3. Click [Settings-Human-robot collaboration-Dynamics parameters] to enter the "Dynamics parameters" interface.



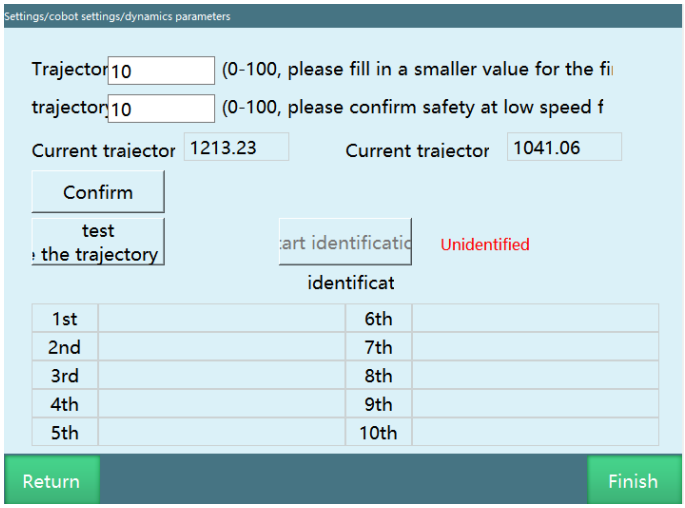
4. Read the instructions carefully.



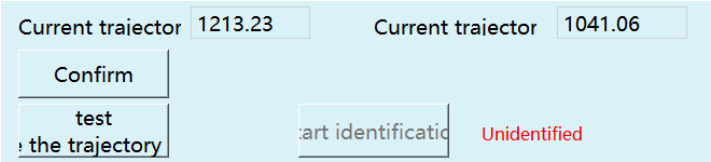
5. After reading all the instructions, click "Read and agree" and click "Start identification".



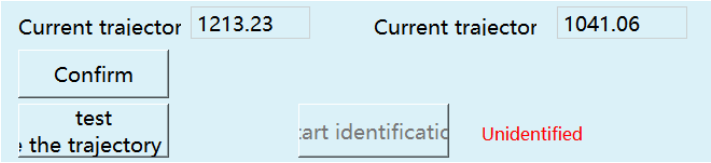
6. After entering the operation interface of identification, fill in 10 for "Trajectory range" and 10 for "Trajectory speed".



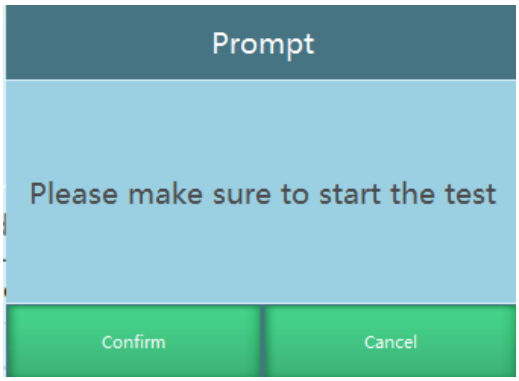
7. Click "OK", check the current trajectory Z maximum value and current trajectory Z minimum value, check whether the range is reasonable, confirm that the trajectory can be reached before entering the next step.



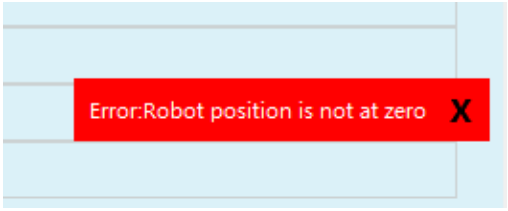
8. Click "Test (make sure the trajectory is safe)".



9. A test prompt window will pop up, click "OK".



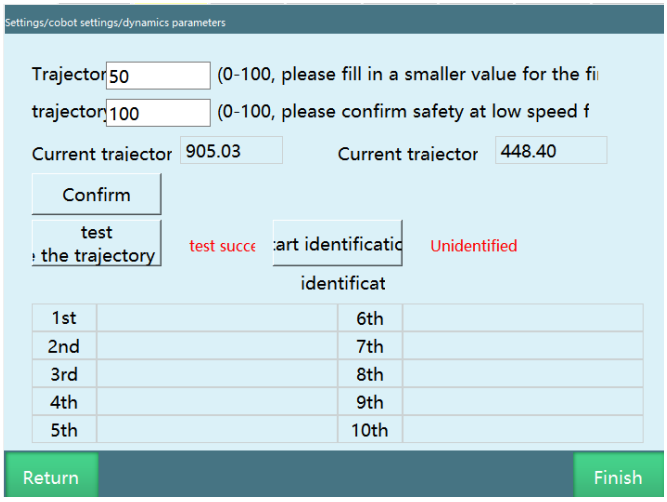
10. If an error is reported, please follow the prompt to return to zero point first.



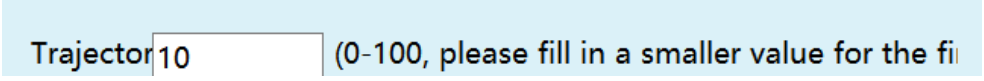
11. If no error is reported, a pop-up will indicate "Testing in progress..."

12. During robot movement, you can stop the robot by pressing "Stop" button, switching modes, or pressing the emergency stop button at the top right of the teach pendant.

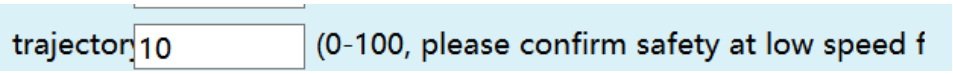
13. When the test is completed, the interface will prompt "Test successful".



14. If the trajectory range is small, the trajectory range can be enlarged. In principle, the larger the trajectory range, the higher the accuracy of identification.

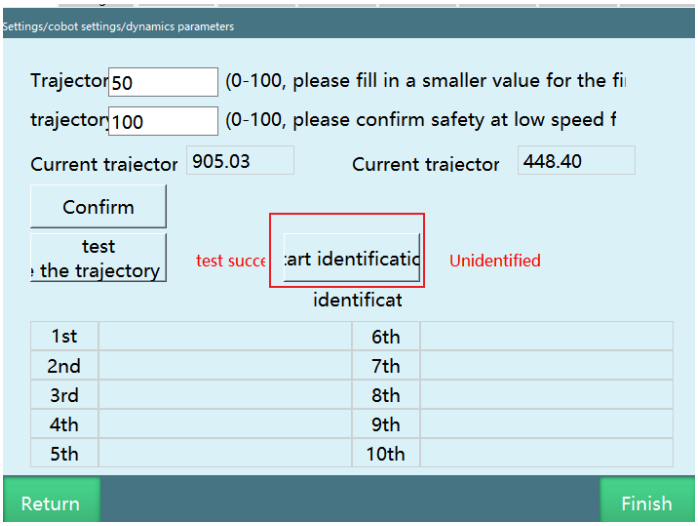


15. The trajectory speed can be slow when testing, but the trajectory speed must be set to 100 when identifying.

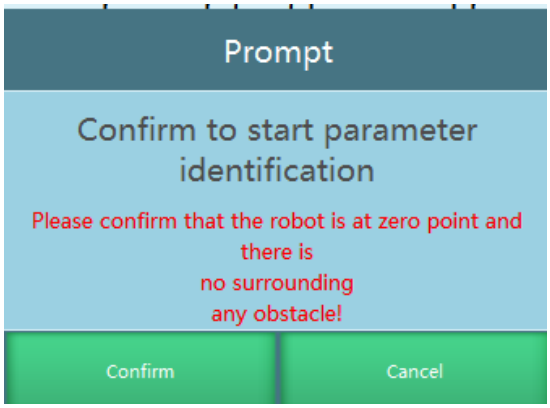


16. Maximize the trajectory range on the basis of ensuring safety, once the speed is set to 100, you can start the identification.

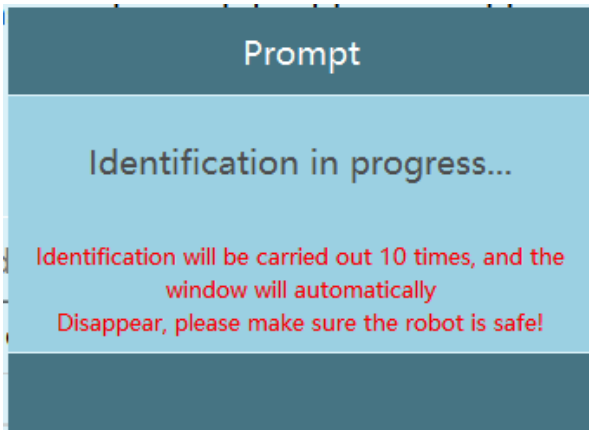
17. Click "Start identification".



18. Re-confirm that the trajectory is safe and people are away from the robot, then click "OK".

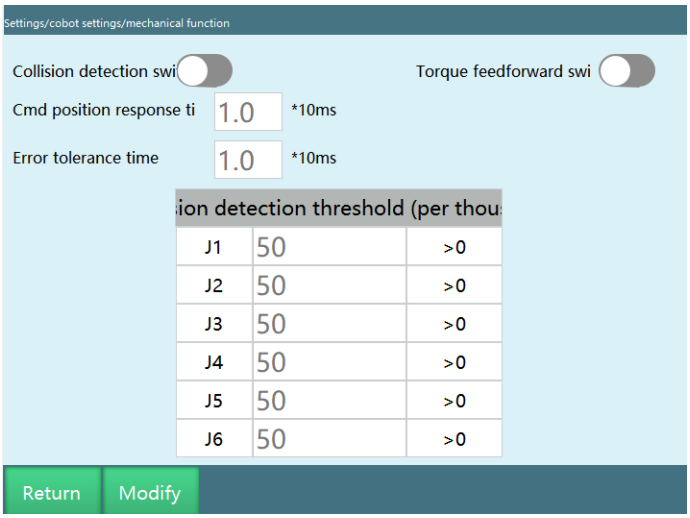


19. Then a pop-up window will appear to indicate that identification is in progress, please do not approach the robot before the end of identification. The robot may run the next trajectory at any time.



Mechanical functions

The mechanical functions include collision detection, torque feedforward and drag teaching, you need to enter **"Settings/Human-robot collaboration/Mechanical functions"** to set the collision detection and torque feedforward functions.



Collision detection switch: When turned on, the robot will perform collision detection based on sensitivity. Usually, you need to find the value that will not determine a collision when the robot is running, and then the robot will run normally

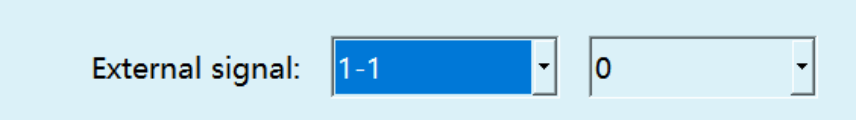
Instruction position response time: The robot body has touched something during operation, but the system will delay reporting an error because of the set time; when the time is up, the error appears and the robot is powered down

Error allowance time: PID adjustment causes torque fluctuations that mistakenly trigger a collision warning, this function is to prevent this phenomenon from occurring, and the alarm will not appear if the torque returns to the normal range within the set time

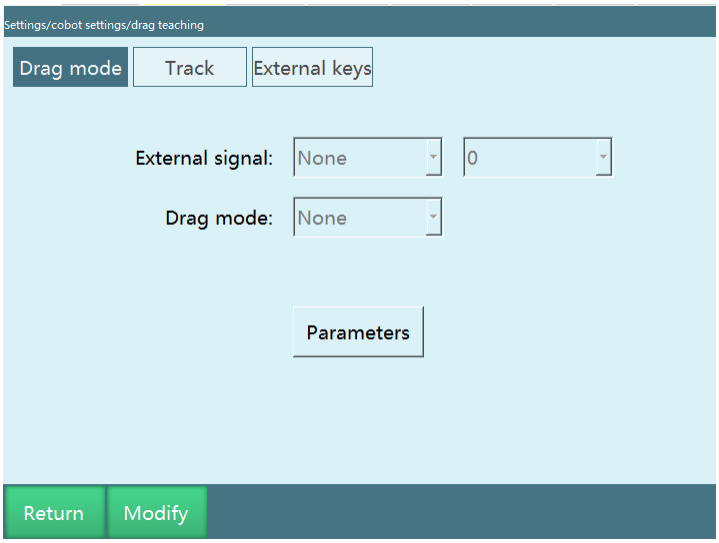
Drag teaching

For "Drag mode", you can choose between "Torque" and "3D mouse".

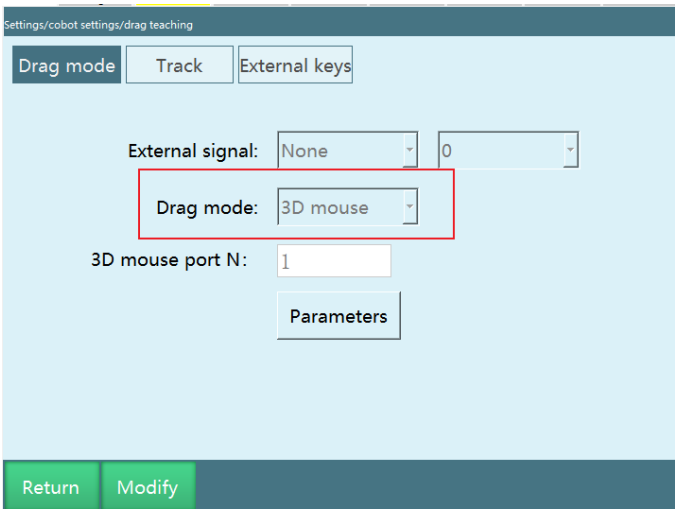
You can set IO signals to switch between drag mode and jog mode, you can also switch between them using the ○ button on the teach pendant or the "Teach mode" button in the "Monitor" window.



You can switch to drag mode by triggering the external trigger signal (for example, the signal trigger mode is 0, then it must switch from 1 to 0 to take effect, if it is based on IO signals, then the ○ button will not take effect after the IO trigger).



Select "3D mouse" for "Drag method" after clicking on the "Modify" button.

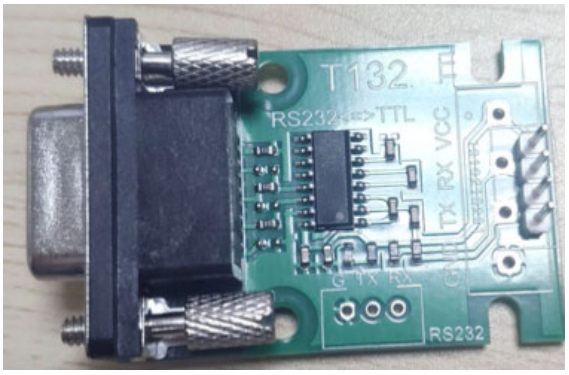


3D mouse

Accessory description

3D mouse-related accessories:

1. TTL to RS232 adapter



2. 5V power supply
3. 3D mouse body
4. Cable storage box
5. 3D mouse fixing plate

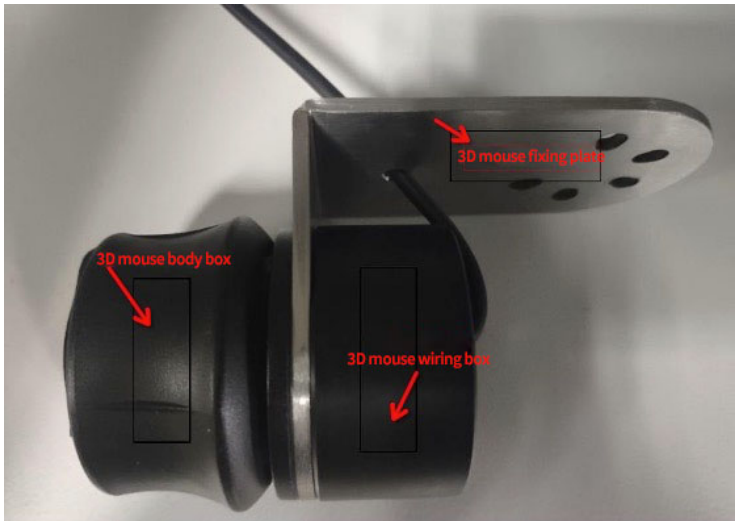
Wiring definition:

4	RxD (input)	orange

Wiring diagram:

Installation:

The installation parts of the 3D mouse are divided into 3D mouse body, 3D mouse wiring box and fixing plate.

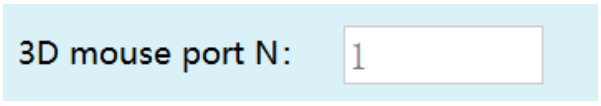


The 3D mouse cable box is used to store some of the 3D mouse connection cables and the fixing plate is used to mount the 3D mouse on the end of the robot. The 3D mouse can be mounted on the end of the robot after the components are assembled as shown above. It is also possible to use the 3D mouse without mounting it on the end of the robot, but the sense of direction when dragging is not as intuitive as when it is mounted on the end of the robot.

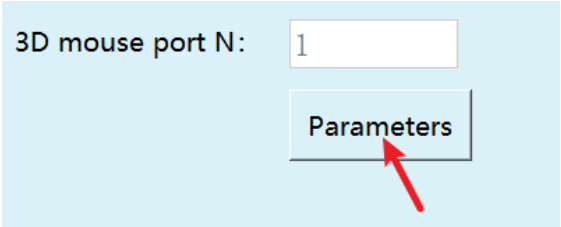
Power supply: External 5V power supply.

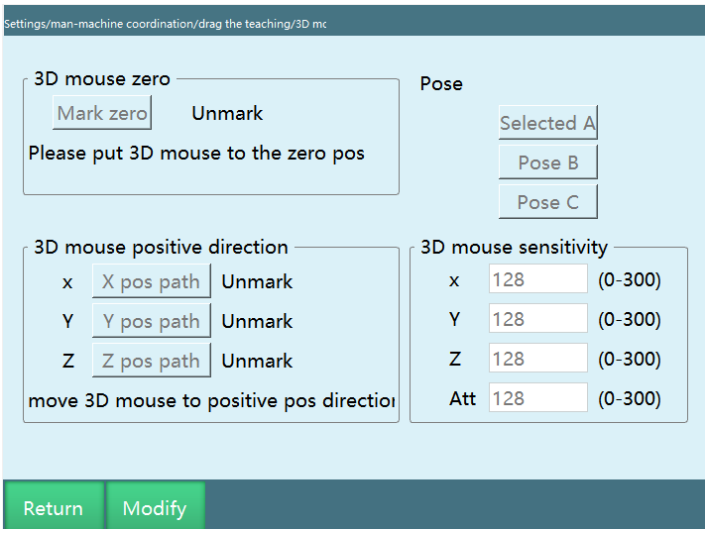
Wiring setup: The mouse conversion cable is plugged into the Com1 serial port of the controller and the Com1 serial port needs to support RS232 communication to be used directly.

Instructions for use and precautions:



3D mouse port number: equivalent to COM port on the controller; select the COM port with the number you filled in.





If you install the 3D mouse on the robot body, make sure the robot is safe to use before you use it！ ！ ！ ！ ！

Mark zero: Mark the 3D mouse zero position, "Unmarked" means no zero point has been marked, and "Marked" will be displayed when it is marked.

Usage: Click "Modify", then click "Mark zero" to finish marking, no need to move the mouse.

Mark positive direction: Mark X, Y, Z positive directions, "Unmarked" means no direction has been marked, and "Marked" will be displayed when it is marked. If the communication fails after pressing, the system will show communication failure, and the direction will follow the last marked direction in this case.

Usage: Click "Modify", then click the "Mark direction" button, then press the corresponding direction of the mouse, when the indication of successful direction marking appears, it means the marking of that direction is completed.

Pose control: Select the pose controlled by the mouse rotation, you can choose to control pose A, B, C.

Usage: Click "Modify" and click the corresponding pose button to complete the selection.

3D mouse sensitivity: Used to control the sensitivity of the 3D mouse to control the corresponding direction and posture.

Usage: Click "Modify", enter the value, the value range is 0-300, the larger the number, the higher the sensitivity.

Key sequence for first use:

1. Click "Modify"
2. Mark the zero point
3. Mark XYZ directions
4. Set the sensitivity value
5. Click "Save"

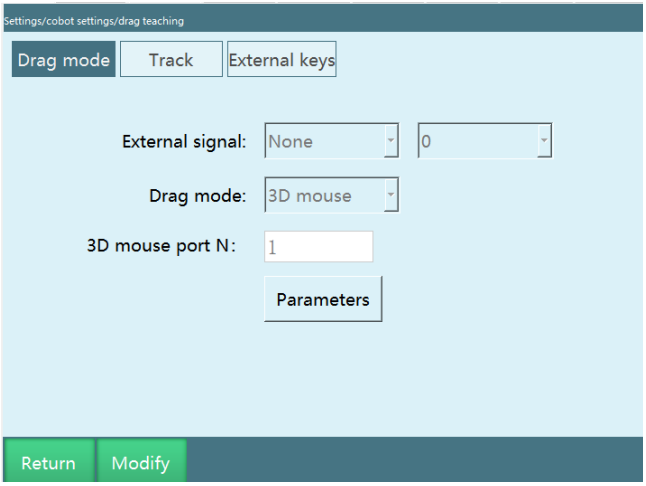
3D mouse control of robot movement

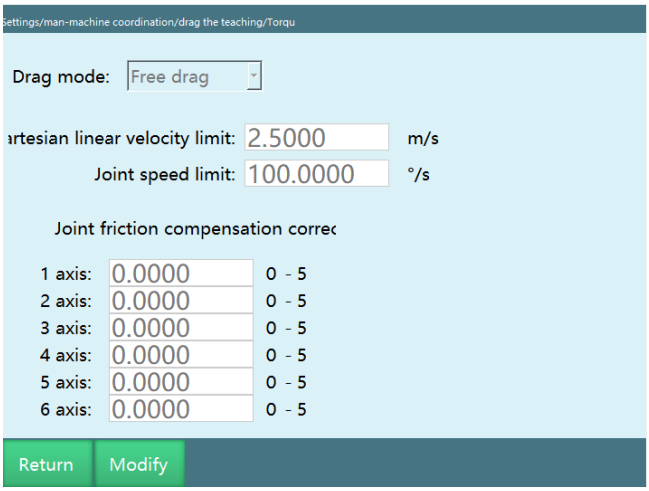
1. Complete zero point setting and direction marking
2. Enable the servo via the teach pendant
3. By pressing the 3D mouse in the corresponding direction, the robot can be controlled to move in that direction
4. 3D mouse supports robot motion in all coordinate systems, but the direction correspondence only applies to the Cartesian coordinate system, and the other coordinate systems are used to control individual joint movements, which is different from the motion in the Cartesian coordinate system

Torque dragging

Parameter description

Parameter setting interface





Drag mode: You can choose from three modes, such as free dragging, position dragging and posture dragging

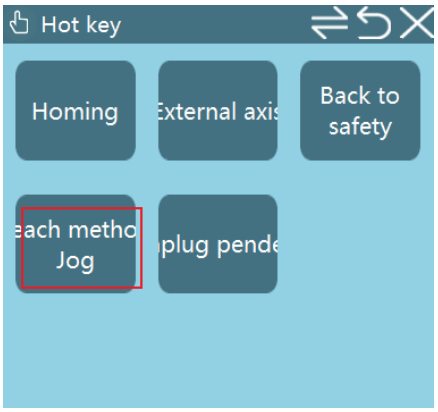
Cartesian space line speed limit: temporarily invalid

Joint space speed limit: the maximum speed when dragging, the robot will power down and stop when the limit is exceeded

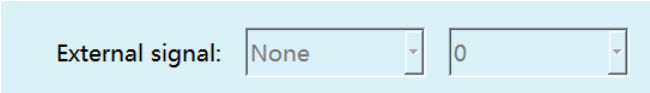
Joint friction compensation correction factor: range 0-5, the closer the parameter is to 5, the more flexible the joint is; it is recommended that the parameter be tested from 0.

Drag mode switching

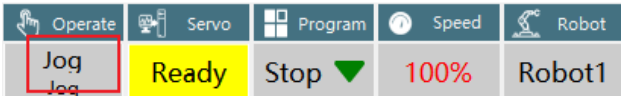
1. Switch using the Teach pendant - Monitor - Shortcut - Jog method button



2. Switch using the ○ button (the bottom left button) on the teach pendant
3. Switch using external signal (DIN input signal)

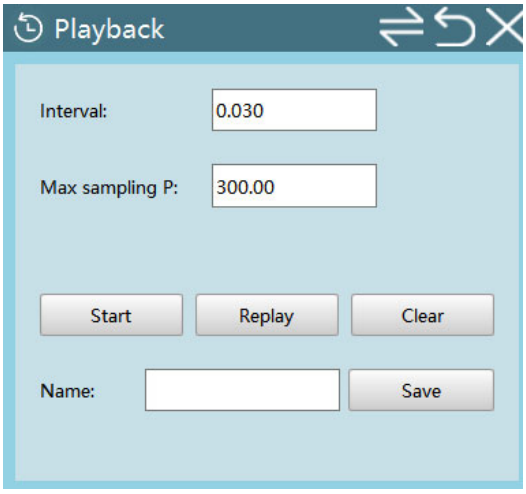


Check if the status bar of the teach pedant is in drag mode



After entering drag mode, power up and drag the robot

Drag teaching trajectory playback

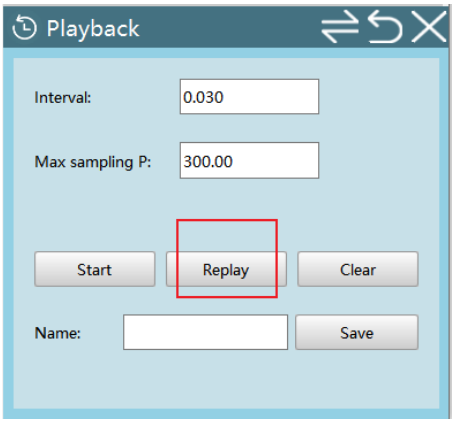


Sampling interval: unit s, acquiring points at every sampling interval.

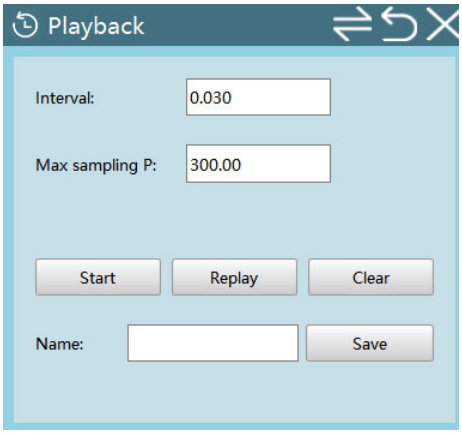
Maximum number of sampling points: range 200 to 12000, the maximum number of points of a recorded trajectory.

Operation steps:

1. Enter Monitor - Shortcut - Trajectory playback interface

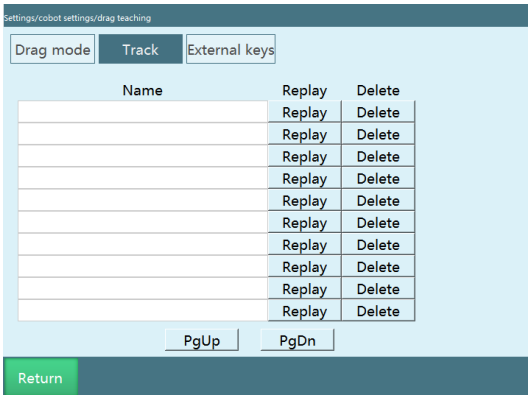


2. Switch to drag mode, set sampling interval and maximum number of sampling points



3. Power up, click the "Start" button in the "Monitor" pop-up and start dragging the robot
4. Click "Stop" or wait until the point recording is completed, the interface shows that the trajectory has been recorded
5. At this point you can power down, switch to jog mode, click the "Playback" button to play back the trajectory you just dragged
6. Enter the trajectory name and click "Save" to save the trajectory you just recorded
7. Clear: Clear the recorded trajectories

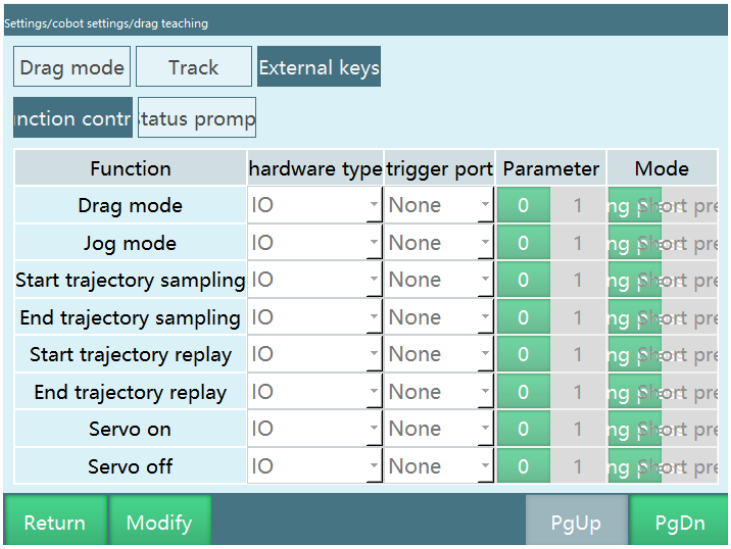
Trajectory management



Enter "Settings-Human-robot collaboration-Drag teaching-Trajectory management" interface

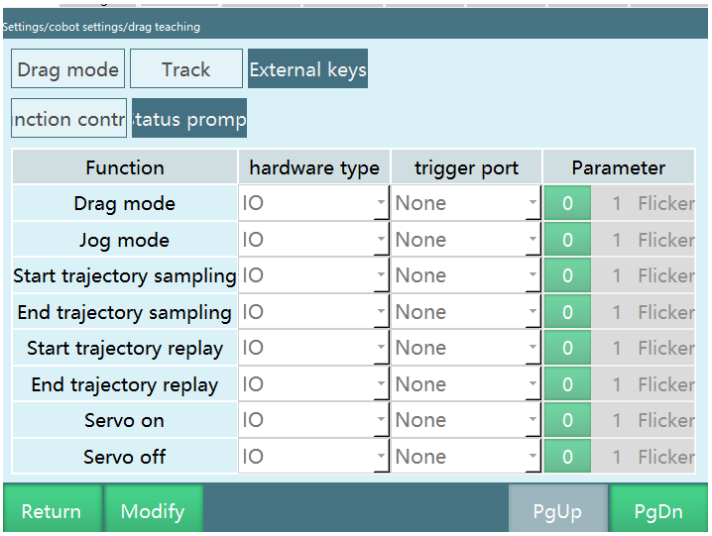
Here you can play back and delete the saved trajectories

External keys



In the "External keys" interface, you can control the robot's drag/jog mode, start/end track acquisition, start/stop track playback, up/down enable and other functions through the set trigger port, parameters and methods

(Note: The same type can use the same trigger port, the trigger signal must be rising edge or falling edge to be valid, and the long press needs to meet the continuous input of 3-10)



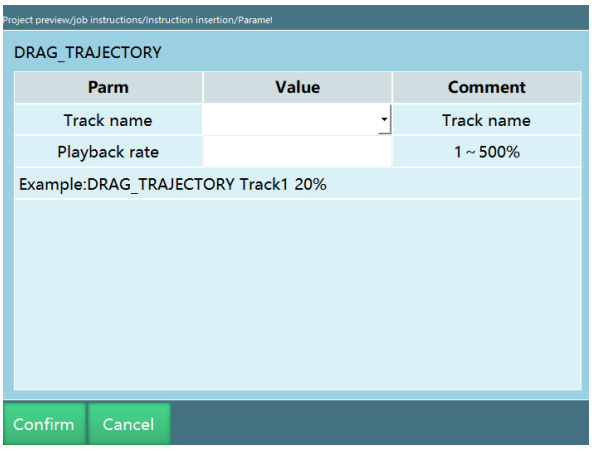
When the status prompt interface satisfies the corresponding function, IO will make a corresponding response according to the set trigger port and parameter type

Drag teaching instructions

DRAG_TRAJECTORY instruction

This instruction is used to call the trajectory playback record. When the playback rate is filled in 100%, it means the current dragging speed, 500% means five times the current dragging speed, and so on.

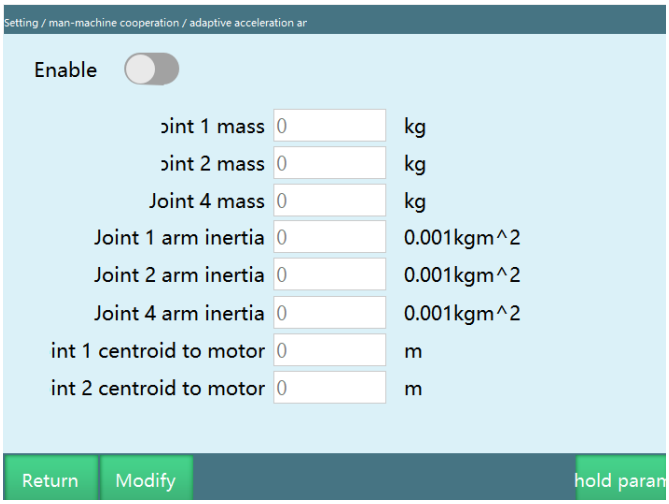
Note: The running speed of this instruction is the dragging speed x playback rate, and the status bar speed does not affect the speed of this instruction.



Adaptive acceleration/deceleration

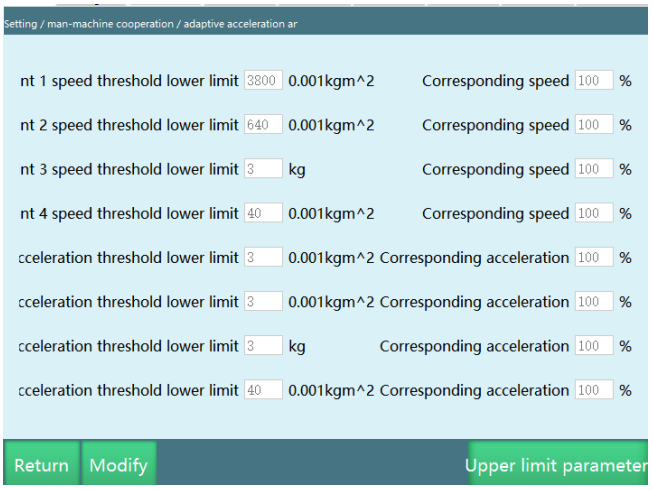
When the adaptive acceleration/deceleration enable switch is on, it protects the motor from excessive torque during motor movement (only supports 4-axis scara robots)

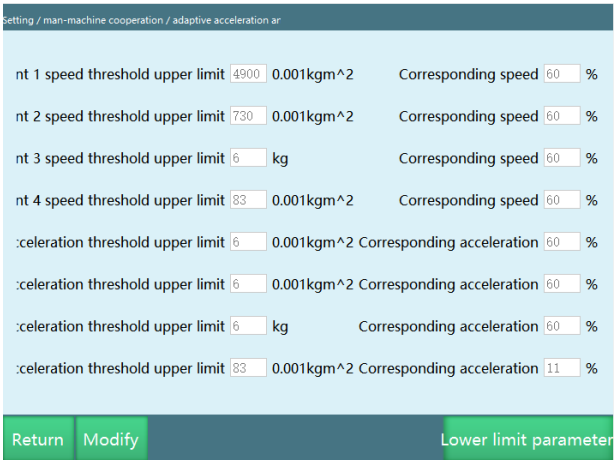
You can enter **"Settings/Human-robot collaboration/Adaptive acceleration/deceleration"** to set the adaptive acceleration/deceleration. The relevant steps are as follows:



Fill in the appropriate parameters according to your needs and turn on the enable switch to take effect.

Threshold parameters: The interface to fill in the upper and lower speed and acceleration limits, as shown below





Load drag teaching process

1. Perform identification according to the dynamics parameter process
2. Install the load after identifying successfully
3. Then set up the parameters in the drag teaching interface, and the drag mode can be selected from torque and 3D mouse.

Switching between drag mode and jog mode can be done using the ○ button on the teach pendant, "Teach mode" button in "Monitor" interface, and external trigger IO signals.

Notes

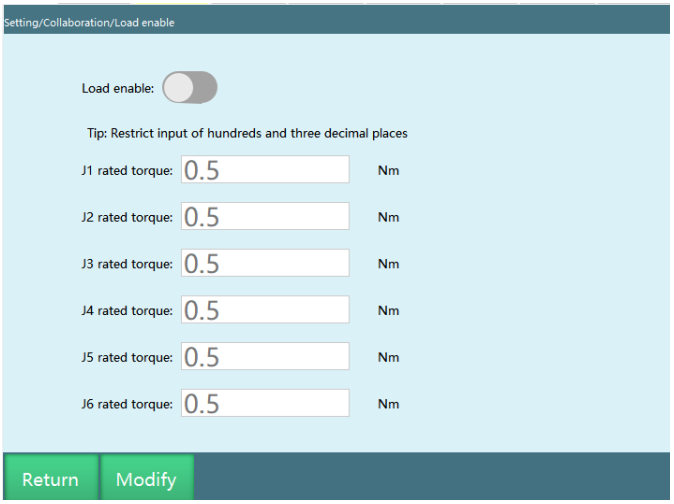
- The ○ button and the "Teach mode" button are not available after switching to drag mode using the IO signals.

4. Finally, set the load enable parameters (load parameters are set in the tool hand interface and load enable interface respectively). Turn on the load enable switch, save the settings and then switch the teach pendant from jog mode to drag mode. You can drag after powering up.

- Load enable interface settings are as follows: Settings - Human-robot collaboration - Load enable

Load Enable: Determine whether to enable the load function or not. When the load enable switch is turned on, the system will calculate the load torque when the robot arm is running according to the load parameters under the selected load number.

Rated torque: the rated torque of each joint motor (refer to the rated torque in the servo parameters)

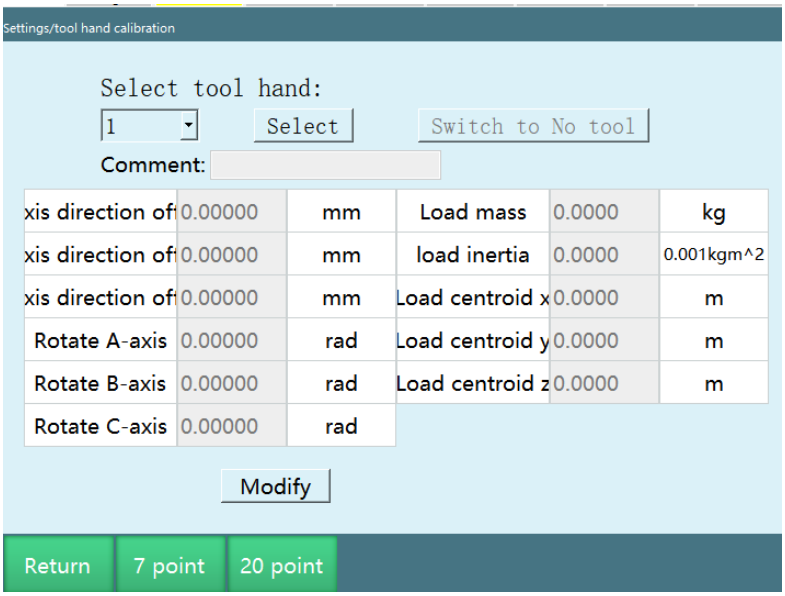


- Tool hand interface settings are as follows: Settings - Tool hand calibration

Load number (i.e. tool hand number): The tool hand number is the load number.

Load mass: total mass of the robot end load

Load inertia: the rotational inertia of the load



The following XYZ are based on end coordinate system. (End coordinate system axis confirmation method: in the case of no tool hand, go TX, TY, TZ under the tool coordinate system to confirm the direction of XYZ)

X: Offset (distance) of load center of mass along X direction, starting from the center of flange

Y: Offset (distance) of load center of mass along Y direction, starting from the center of flange

Z: Offset (distance) of load center of mass along Z direction, starting from the center of flange

XYZ supplementary note: It is recommended that after installing the load, adjust the axis 6 zero point at the zero position of the robot, so that the load center of mass is directly in front of the robot, at this time, X is the horizontal distance between the load center of mass and the axis 6 center, Z is the vertical distance between the load center of mass and the axis 6 center, and Y is 0

Notes

- The above specific parameters can be consulted with the manufacturer