ATOM Teleoperation User Guide

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SHENZHEN DOBOT CORP LTD

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Preface

Purpose

This document is used to introduce the methods for using teleoperation with the DOBOT ATOM series robot.

Intended audience

This document is intended for:

- Customer
- Sales Engineer
- Installation and Commissioning Engineer
- Technical Support Engineer

Revision history

Date	Version	Revision history
2025/12/25	V1.2	Separate the teleoperation section into a standalone manual.
2025/10/15	V1.1	Update Connect to the Robot WiFi.
2025/09/26	V1.0	The first release

Symbol conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
DANGER	Indicates a hazard with a high level of risk which, if not avoided, could result in death or serious injury.
WARNING	Indicates a hazard with a medium level or low level of risk which, if not avoided, could result in minor or moderate injury, robot arm damage.
NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in robot arm damage, data loss, or unanticipated result.
NOTE	Provides additional information to emphasize or supplement important points in the main text

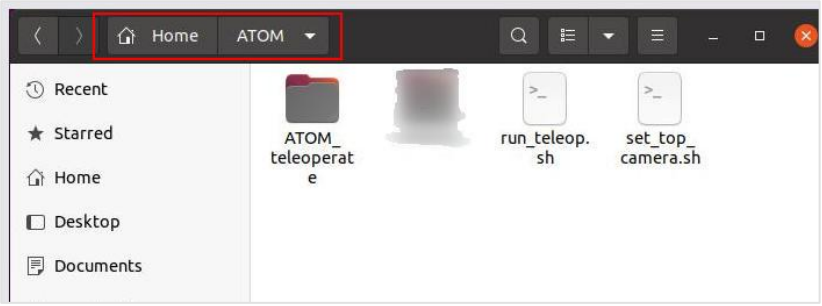
Content

1. Overview

Using VR headsets (Quest3, Apple VisionPro) to recognize human gestures and map them via algorithms to control the upper body of the DOBOT ATOM (including dual arms, dexterous hands, and head). Simultaneously, the operator views the robot's first-person perspective through VR, enabling teleoperation of the robot and facilitating data collection.

2. Initiating the Teleoperation Program

Copy, extract, and save the teleoperation program firmware into the ATOM folder under the Home directory of the onboard PC2 (create the folder manually if it does not exist). After extraction, the file directory path should be as follows:

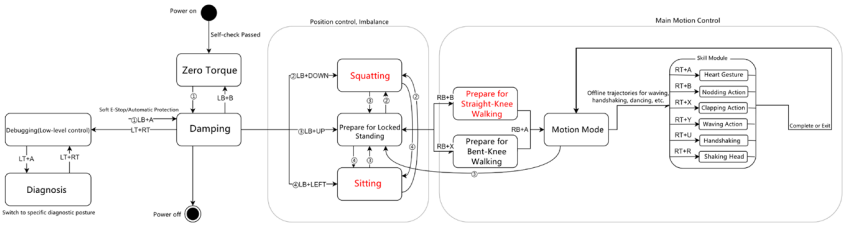


2.1 Switching Robot Modes

Once the robot is powered on, switch it to teleoperation mode using the buttons on remote controller.

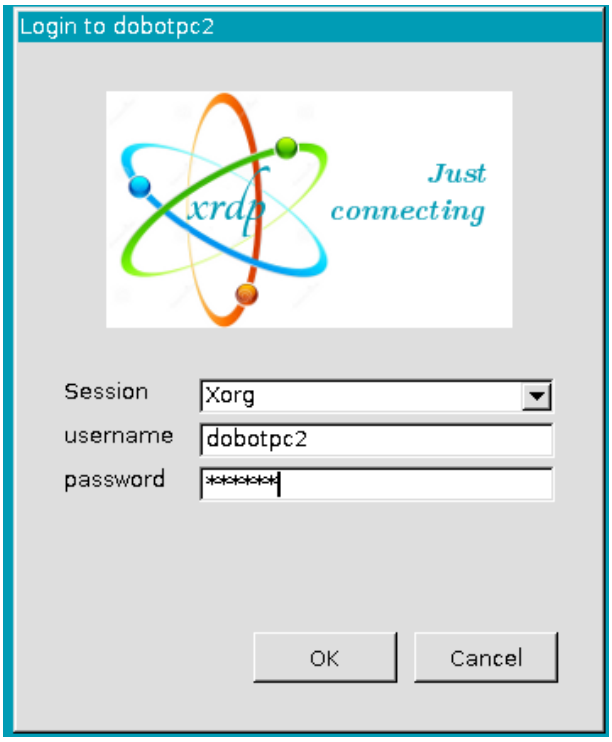
The modes that support upper limb teleoperation include: Debugging, Position Control, and Main Motion Control Walking Mode (refer to the state machine control flowchart below for specific button operations).

- When the robot is supported by a stand, it can enter debugging mode.
- Without the support of a stand, the robot can enter main motion control walking mode and activate the motion control model.



2.2 Accessing Onboard PC2

1. Connect a laptop to the robot via wireless or wired connection.
   - **Wireless Connection:** Connect to the WiFi corresponding to the target robot, such as "ATOMMX-4521-0731" (MX indicates that the target robot is the Max version, and the following number is the robot's serial number).
   - **Wired Connection:** Use a wired connection to the robot's switch Ethernet port.
2. Open Remote Desktop and enter the IP "192.168.8.13:3390" with the username "dobotpc2" and password "123456".

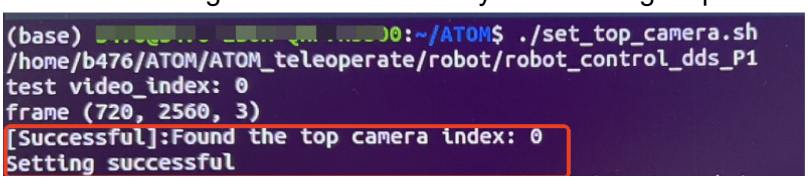


2.3 Starting the Teleoperation Program on PC2

1. Ensure there are no obstacles around the robot to prevent the arm from colliding when initializing the teleoperation position.
2. Set the following parameters:
   a. **Configure the index for the head stereo camera:** The USB index for the head stereo camera might change each time the system is powered on or if a USB device is plugged in or out from PC2.

   Automatic Setting Method: Navigate to the ATOM directory and right-click to open a terminal (all subsequent command operations on PC2 should be performed in this directory). Enter the command "./set_top_camera.sh".

   Successful configuration is indicated by the following output:



b. Configure Other Parameters

Open the configuration file located at /home/ATOM/ATOM_teleoperate/teleop/teleop_confing.ini and adjust the following parameters as necessary, while leaving the other values at their defaults:

Parameter name	Default Value	Type	Description	Range/Unit
save_data_fps	20	int	Frame rate for data saving	1 ~ 50
save_data_path	/home/dobotpc2 /ATOM/datasets/	str	Address for saving the dataset (for all tasks)	-
project_name	new_dataset	str	Task dataset folder name	-
top_camera_id	0	int	Index for the head stereo camera, specified as the video index under /home/dev/ in the Linux system. This can be set via automatic acquisition.	-
top_camera_resolution	(720,1280)	Tuple	Resolution of the head stereo camera (width, height)	-
top_camera_fps	60	int	Frame rate for the head stereo camera	1 ~ 100
use_hand_camera	False	bool	Whether to use the wrist camera	True / False
left_hand_camera_sn	230322270903	str	Serial number of the left-hand camera	-
right_hand_camera_sn	230322273859	str	Serial number of the right-hand camera	-
human_arm_length	0.60	float	Operator's arm length, used for scaling and mapping adjustments with the robot's arm stretch	0.5 ~ 1(m)
pinching_threshold	0.015	float	Threshold for thumb and index finger pinch suction	0 ~ 0.040(m)
thumb_rotation_threshold	150	int	Robot thumb rotation value	0 ~ 300
thumb_bending_threshold	490	int	Robot thumb bending value	300 ~ 600
indexfinger_bending_threshold	410	int	Robot index finger bending value	300 ~ 600

3. Run the Teleoperation Program

Enter the command "./run__teleop.sh" to start the teleoperation program. Wait for a moment for the arm to automatically move to the initial position.

NOTE

- For the first run, enter the command "chmod +x run_upper_teleop.sh" to grant execution permission, then execute "./run__teleop.sh".
- If you encounter an error indicating that the Atom environment cannot be activated, first enter "source ~/.bashrc" and then run the command again.

3. Starting Teleoperation

The text display in VR is as follows:

- Control: Indicates the status of human-machine synchronization. Status: **On** (activated) / **Off** (deactivated)
- Record: Indicates the status of data collection. Status: **On** (activated) / **Off** (deactivated)
- Trigger: Posture trigger status.

  Fingers open: **Fok/Fno**

  Arm's second joint exceeds 30°: **Aok/Ano,c**

  Wrist horizontal: **W1ok/Wno**

  Wrist vertical with palms facing inward: **W2ok/Wno**

  When the pose triggers human-robot synchronization: **Control pose...**

  When the pose triggers data collection: **Record pose...**

3.1 Entering Teleoperation via VR Interface

Connect to the Robot WiFi

Set up a wireless connection to the WiFi corresponding to the target robot, such as "ATOMMX-4521-0731", with the password "12345678".

Access the VR Browser Interface

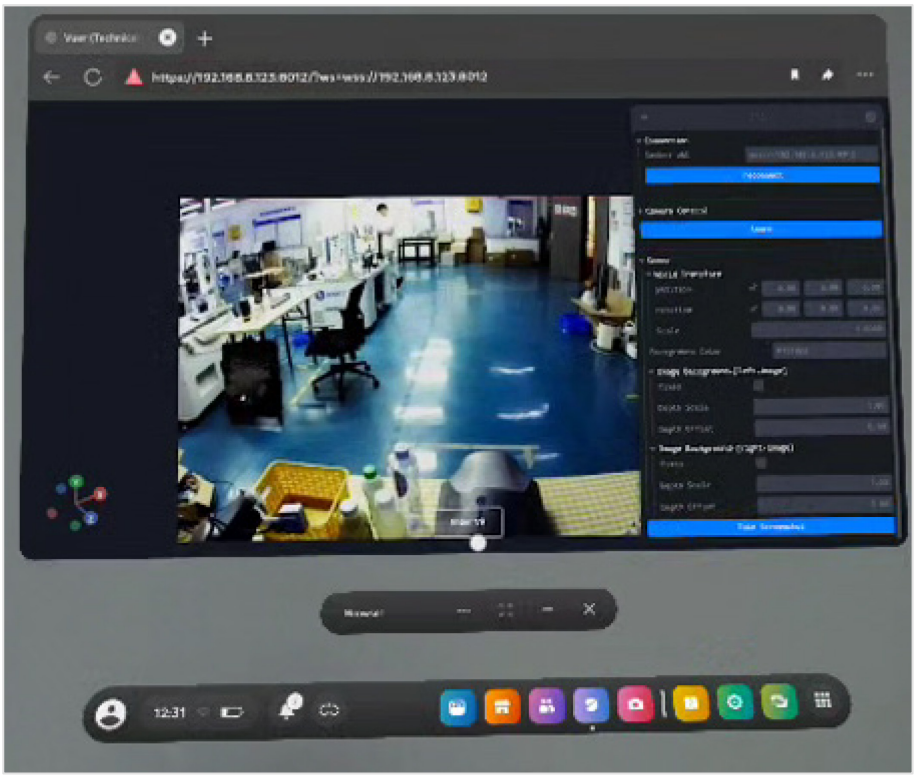
Visit the DOBOT ATOM VR website: https://192.168.8.13:8012/?ws=wss://192.168.8.13:8012.

If you can see a live feed from the camera, it indicates that the system is functioning normally.

> **NOTICE**
>
> Please ensure that the browser is positioned directly in front of the person, and refrain from opening multiple teleoperation browser windows simultaneously

Enter Teleoperation Immersive Mode

Click "**Enter**" at the bottom of the screen to access immersive mode. If a pop-up message appears, please click "Allow".



3.2 Human-Robot Synchronization

1. Open both hands and approach the robot with the following three conditions met simultaneously (the interface will display "Trigger: Control pose...") and hold for 3 seconds:
   - **a.** Fingers spread open
   - **b.** Arm's second joint exceeds 30°
   - **c.** Wrist horizontal
2. When the **Control** status in the top left corner of the screen shows red **"On"**, it indicates that synchronization has been achieved.
3. Keep both hands in a fist to avoid triggering the pose that stops synchronization.

3.3 Start Data Recording (Optional)

1. Open both hands and approach the robot with the following three conditions met simultaneously (the interface will display "Trigger: Record pose...") and hold for 3 seconds:
   a. Fingers spread open
   b. Arm's second joint exceeds 30°
   c. Wrists vertical with palms facing inward
2. When the **Record** status in the top left corner of the screen show **red "On"**, it indicates that data recording is active.
3. Control the robot's operation tasks. During the entire process, image data from various cameras (head stereo camera, two wrist cameras) and the robot's upper limb body data (including 2*7 joint angles for dual arms, 2*6 degrees of freedom for the dexterous hands, and 2 degrees of freedom for the head, all in radians) are saved under the set **data file storage path**. The automatically generated directory structure is as follows:

   |----------
   |--Data file storage path xxxxx #Set **data file storage path**
   |--------collect_data #All episode data
   |------------2025xxxxxxx #Folder named with data collection timestamp, one episode of task data
   |------------------observation # Robot upper body data
   |--------------------------0.pkl #First frame body data, internal structure: **obs** (28-dim array), **action** (28-dim array). For 28 data indices, see Table 1 below.
   |--------------------------1.pkl
   |--------------------------xx.pkl
   |------------------top_left #Image data from the left of the head stereo camera
   |--------------------------0.jpg #First frame image data
   |--------------------------1.jpg
   |--------------------------xx.jpg
   |------------------top_right #Image data from the right of the head stereo camera
   |------------------wrist_left # Left wrist camera image data
   |------------------wrist_right #Right wrist camera images
   |------------------trajectory.txt #Robot upper body trajectory data for one episode task
   |----------

Table 1 Degrees of freedom corresponding to the 28-dimensional data indices respectively

Index		Corresponding Degree of Freedom	Index		Corresponding Degree of Freedom
0-6 Left Arm		1~7 Joints	13~19 Right Arm		1~7 Joints
7~12 Left-hand fingers	7	Pinky	20~25 Right-hand fingers	20	Pinky
	8	Ring Finger		21	Ring Finger
	9	Middle Finger		22	Middle Finger
	10	Index Finger		23	Index Finger
	11	Thumb Flexion		24	Thumb Flexion
	12	Thumb Rotation		25	Thumb Rotation
26		Head turn (left and right)	Head turn (left and right)		Head Pitch

3.4 Stop Data Recording (Optional)

1. Approach the robot with both hands open, ensuring the following three conditions are met and maintained for 3 seconds:
   - **a.** Fingers are spread apart
   - **b.** The arm's second joint is greater than 30°
   - **c.** Wrists are vertical with palms facing inward
2. When the "**Record**" status indicator in the upper left corner of the screen turns **red "Off"**, it indicates that data acquisition recording has stopped.

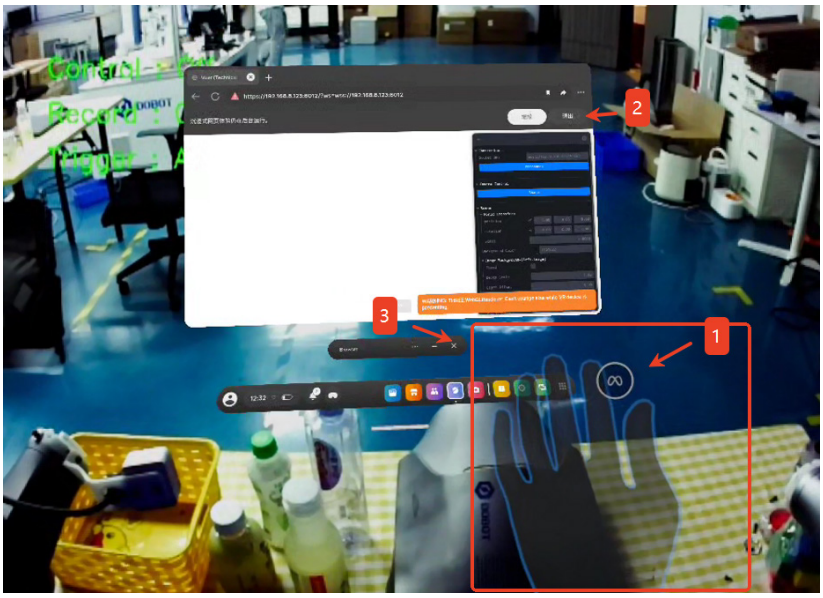
3.5 Human-Machine Synchronization Stop

1. Approach the robot with both hands open, ensuring that the following three conditions are met (the interface displays "Trigger: Control pose...") and maintained for 3 seconds:
   - **a.** Fingers are spread apart
   - **b.** The arm's second joint is greater than 30°
   - **c.** The wrist is horizontal
2. When the **Control** status in the top left corner of the screen shows green **"Off"**, it signifies that the synchronization state has been exited.

> **NOTE**
>
> If the posture consistently fails to meet the conditions for exiting synchronization, an assistant (non-teleoperator) can be requested to stop the teleoperation program on the remote desktop PC2 to force an exit.

3.6 Exit VR Browser Interface

1. Exit the immersive mode interface by pinching your thumb and index finger together with the right palm facing your eyes.
2. Click “Exit” in the top right corner of the browser, and then click the **"x"** at the bottom of the browser window to close it (this may need to be done twice until the browser window is completely closed).



4. Stopping the Teleoperation Program

On the PC2 terminal page where the teleoperation program is running, press **Ctrl+C** once to stop the teleoperation program, allowing the arm to automatically move to the waist position. Press **Ctrl+C** again to complete stopping the teleoperation program.

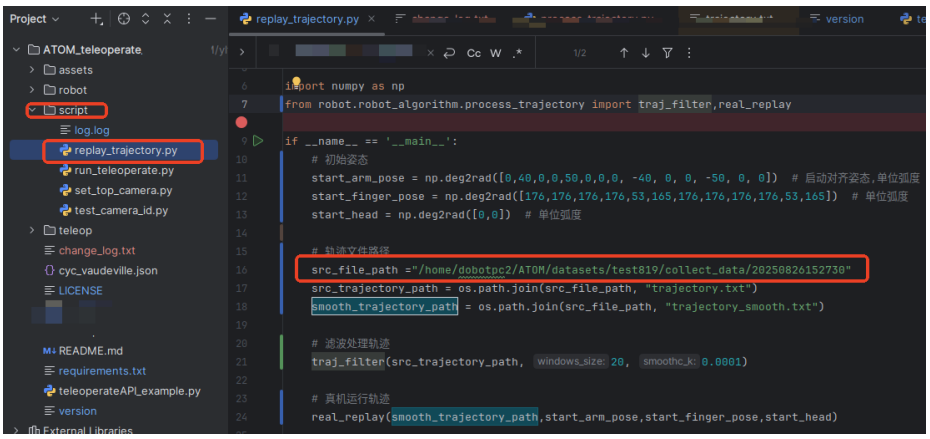
5. Trajectory Reproduction

In certain scenarios, such as when requiring a robot to repeatedly perform a specific motion trajectory or to execute actions via voice trigger, the trajectory recording and reproduction function can be used to obtain the desired motion path. This process involves first recording a trajectory and then having the robot reproduction the offline trajectory.

Operation Method

1. **Teleoperation Trajectory Recording:** Use the teleoperation methods described earlier to record the trajectory. Save the recorded trajectory file as trajectory.txt (refer to Starting Data Recording (Optional) for specific path details).
2. **Executing Trajectory on the Physical Robot:** Open the ATOM_teleoperate > script > replay_trajectory.py file, enter the absolute path of the directory containing the trajectory file, and then run the replay_trajectory.py program.

> **NOTE**
>
> - Operation method for running the replay_trajectory.py program: Right-click to open a terminal window in the ATOM_teleoperate > script directory, type *conda activate Atom* to activate the environment, then type *python replay_trajectory.py* to run the program.
> - If an error occurs indicating the *csaps* library is not found, you can install it by entering the command *pip install csaps* online.



Enter the path where the trajectory file is located

Trajectory Reproduction on the Physical Robot

6. Operation Precautions

VR Usage Precautions

Due to the automatic switching between the Quest's gesture control mode and controller control mode, the system will immediately switch to controller mode upon detecting any controller movement. This will cause the gesture control mode to deactivate.

Therefore, please **remove the batteries** from the controllers before entering VR immersive mode. This prevents an automatic switch to controller mode during teleoperation, which would cause the teleoperation interface to freeze.

Human Orientation

In VR, drag the browser to the forward-facing view and refresh the browser page. At this point, the body and head orientation of the person will be set as the **reference posture**. **The operator should not adjust their posture or move position,** as misalignment with the robot's front may lead to unsafe postures.

If the operator needs to adjust their posture, adjustments should be made while in the stopped teleoperation sync state. Once posture adjustments are complete, drag the browser to the forward-facing view again, refresh the browser page, and enter the teleoperation sync state once more.

Operator's Hand Position

The operator's hands should be positioned in front and below the VR headset, at least 20cm away from the headset. Avoid retracting hands to the waist or behind the body, as this may lead to unrecognized positioning and cause the robot to assume an unsafe posture.

When both hands obscure each other, it can affect the visual recognition of gestures, leading to instability or erratic finger posture detection.

Notice During Head Movement

The recognition of the hand's end posture is relative to the VR headset orientation. When the operator moves their head, it may cause a certain degree of movement in the robot's hand. Therefore, attention must be paid to potential collisions between the robot's hand and the environment.

Notice When Removing VR Headset

Ensure to exit the teleoperation sync state or stop the teleoperation program before removing the VR headset. Otherwise, the robot may assume an abnormal posture or causing collisions.

Impact of Network Environment

Since teleoperation relies on VR communicating with the robot body via local area network (LAN) WiFi, and LAN WiFi is susceptible to interference from the on-site network environment. In settings with multiple networks, there may be delays or lag in both the visual display and robot movements.

Number of Operators

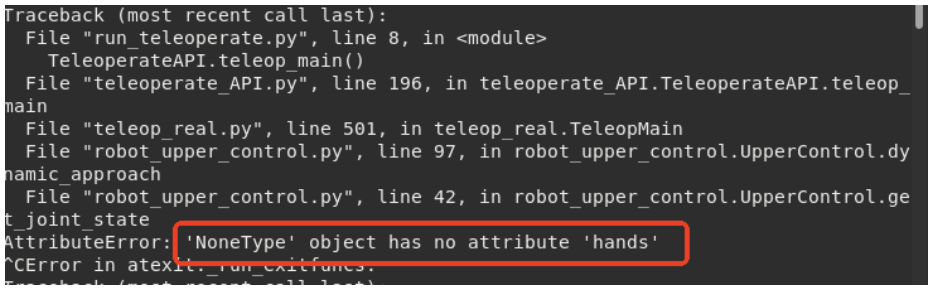
It is recommended to have two operators: one wearing the VR headset to perform teleoperation and another to assist with the following tasks:

- Monitor the robot's surrounding environment for safety and alert the teleoperator to adjust posture if abnormal or unsafe positions are observed.
- In the case of abnormalities, promptly run the stop program on the computer to forcefully exit the teleoperation sync mode, or stop the robot movement using the E-stop button.

7. FAQ

Issue

When running the teleoperation program, the error 'NoneType' object has no attribute 'hands' is reported.



Solution

The error may be due to the dexterous hand configuration not being enabled (it is disabled by default). Please enable the dexterous hand configuration.