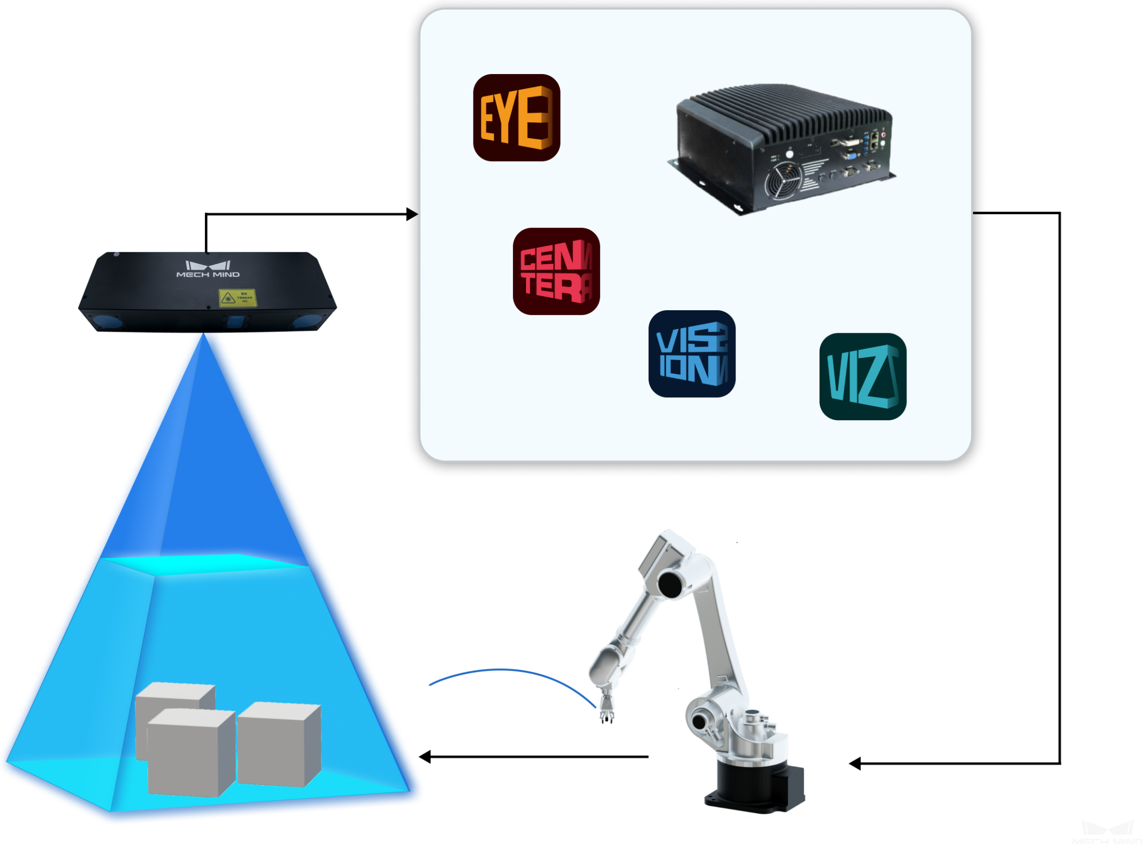
Mech-Mind Quick Guide

Mech-Mind

Jul 01, 2022

CONTENTS



This chapter will guide you to create an application project–box palletizing. You will start from camera installation and be able to control a real robot to pick boxes in the end.

CHAPTER

ONE

OBTAIN THE CAMERA AND ACCESSORIES

Mech-Mind Robotics provides basic camera accessories for our customers.

Standard Hardware

Please check if all the devices and accessories are included in the box. All the devices and accessories you need are shown as below.

Camera × 1

Industrial PC × 1

Dongle × 1

Flange × 1

Calibration Board × 1

Camrea Power Cord × 1

Network Cable × 2

HDMI Cable* × 1

- Dongle: used to decrypt Mech-Mind Software Suite
- Calibration Board and Flange: used to calibrate the camera
- Power Cord: used to connect the camera to the electricity supply
- Network Cable: one is used to connect the camera and IPC; and the other is used to connect the robot controller and IPC
- HDMI Cable: used to connect the computer monitor and IPC

CHAPTER

TWO

MOUNT THE CAMERA

Mounting the camera is like adding a pair of eyes to the robot.

The common mounting methods of the camera include:

- Eye To Hand (ETH): the camera is mounted on a stationary stand independent from the robot.
- Eye In Hand (EIH): the camera is mounted on the flange located at the end of the robot.

In this example project, since there is sufficient space and the objects to be picked are placed in a limited region, the camera will be mounted by using the ETH method. By using the ETH method, the camera needs to be attached to a fixed stand at a certain height above the object to be photographed, and the camera will not move with the robot.

Please mount the camera using ETH method as shown below.

Things you need to pay attention while mounting

1. Location selection: please make sure that the camera is mounted directly above the object plane, and there is enough space for the robot to perform a task without colliding with the camera, as shown below.

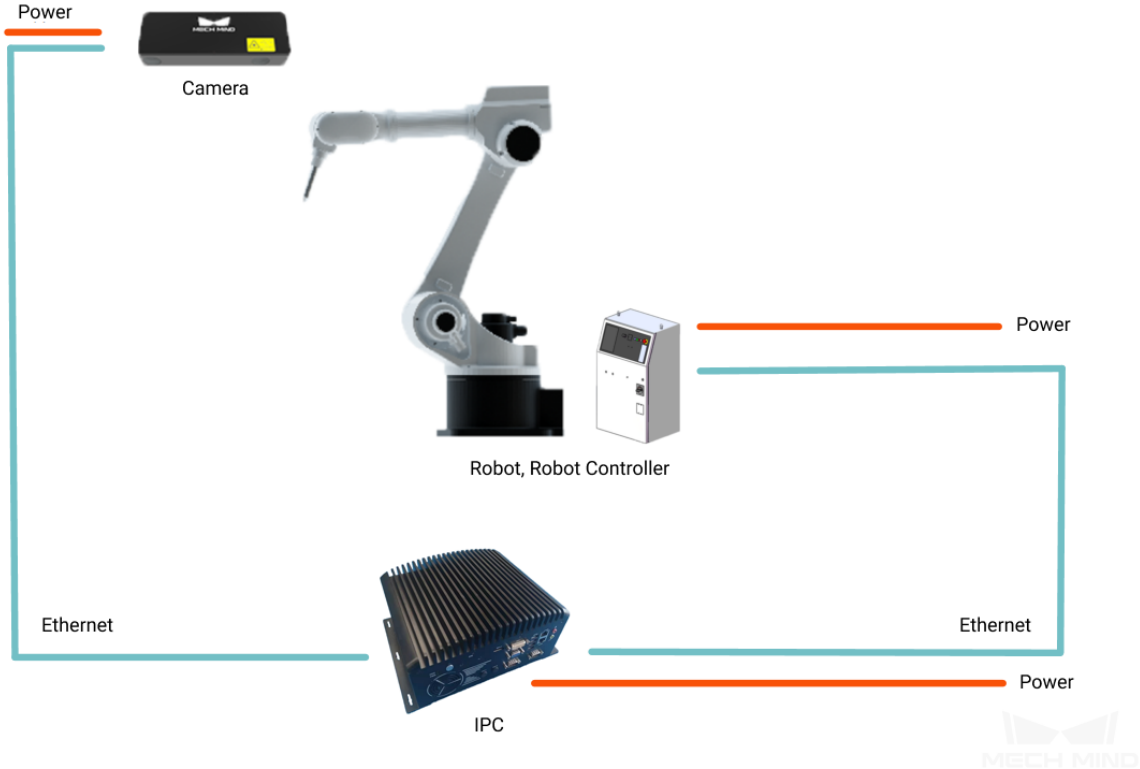
2. Camera stand: you can choose to use an appropriate camera stand based on the actual situation on site.
3. Camera Installation: please make sure that the motion of the robot and the vibration caused by other equipment will not affect the position of the camera. Please refer to cammera_mounting_dimensions to learn more about fixation dimensions of all camera models.

CHAPTER

THREE

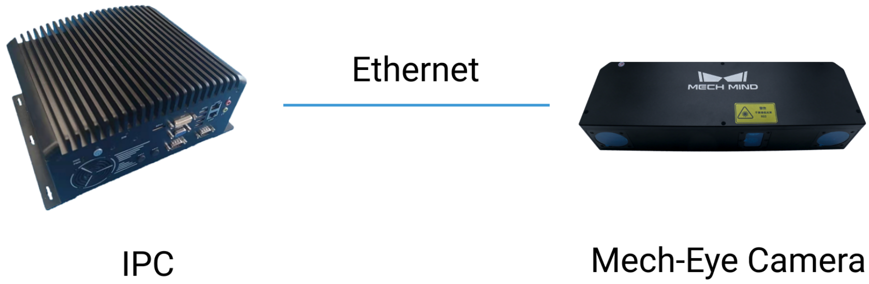
CONNECT THE WHOLE SYSTEM

After mounting the camera and setting up the robot, you need to connect them to the IPC.



3.1 Connect the Camera and the IPC

Use the power cable and Ethernet cables provided by Mech-Mind Robotics to connect the **Camera** and **IPC**. An IPC may have multiple network interfaces, you can choose either one to connect. After connecting, you can change the subnetwork of the correspponding network interface according to actual needs.



3.2 Connect the Robot and the IPC

Use a Ethernet cable to connect the **Robot Controller** and **IPC** . After completing the connection, please turn on the robot controller and the robot teach pendant.

Attention:

1. Please pay attention to which Ethernet port on the robot controller should be used. See robot_integrations for detailed information.
2. Please keep the cables organized. It is dangerous if the cables get tangled up with the robot.

3.3 IP address Setup and Program Loading

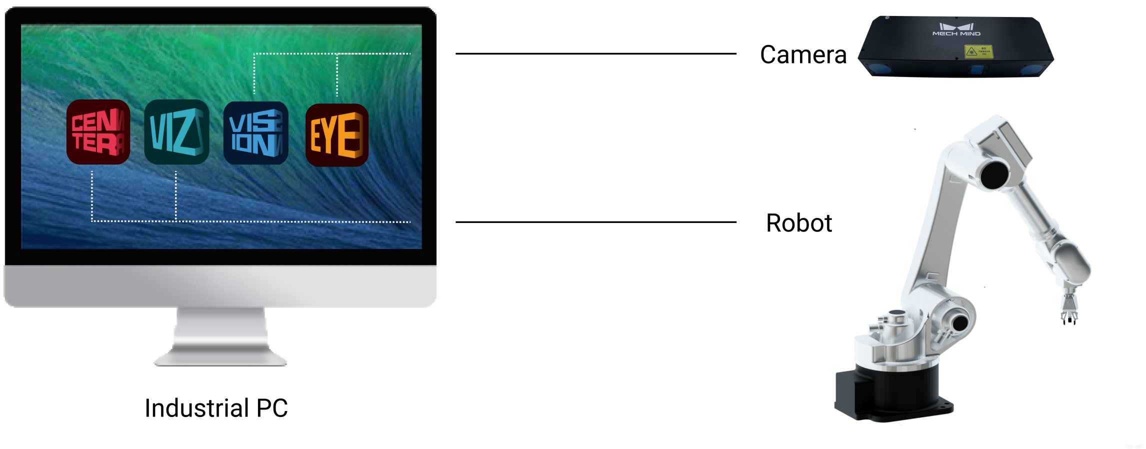
- In this project, the IPC should be connected with both the robot and camera, and therefore two IP addresses are needed. You can select the network interface and subnetwork according to actual needs. Please make sure that the **IP address of connected devices** and the **IP address of IPC** belong to the same subnetwork.
  1. In this project, the IP address of the network interface that connects robot to the IPC is 192.168.2.222.
  2. The IP address of the network interface that connects camera to the IPC is 192.168.2.66.
- In this project, an UR robot is used, which can be controlled without loading a full-control program onto the robot. If the robot model you are using needs to load the full-control program, please refer to robot_integrations.

Now you have completed connecting the whole hardware system. Please check the circuirt and power on. Then please read on to configure the software on the IPC.

CHAPTER

FOUR

INSTALLATION AND CONNECTION



In order to enable the software to control the robot successfully, please operate according to the following steps.

1. *Install Software and DL Environment on IPC*
2. *Configure Mech-Center*
3. *Add a Robot Model and Connect the Real Robot*
4. *Connect and Test the Camera*

4.1 Install Software and DL Environment on IPC

This section will show you how to install software and the Deep Learning Environment. It is recommended to follow the steps when installing.

Prerequisites for using Mech-Mind software

Please refer to software_prerequisites for detailed information.

Install **Mech-Center**

1. Double-click on the Mech-Center .exe file to run the Setup Wizard.

2. Click **Next** and select a location to install the software. You can also choose to create a shortcut on the desktop or on the Start menu.
3. Click **Next** and choose the necessary components (the default one in most cases) to install. Please ensure that there is sufficient storage for software installation.
4. Click **Next** to confirm the installation and wait for installation to complete.
5. If **Open Mech-Center** is checked in the previous step, the executable program will check the operation environment automatically, and you can download the missing components based on the notification or click **Next**. If the box is unchecked, you need to go to the installation directory location of Mech-Center and find **Mech-Center Installer Tool**. Double-click on the .exe file to check the environment.
6. Now Mech-Center is installed successfully.

Install **Deep Learning Environment**

1. The DL Environment is a compressed file in .7z format. Unzip it with a tool that can extract 7z files.
2. After extracting the files, double-click on the Mech_Mind_software_environment_installer .exe file to run the Setup Wizard.
3. Click **Next** and select the installation type according to whether Mech-DLK is needed to train the model.
4. Click **Next** and select the computer type.
5. Click **Next** to check the environment.
6. The result of environment check will be displayed later.
7. Click **Next** and confirm the missing components to be installed.
8. Click **Next** and choose a location to create a shortcut.
9. Click **Next** to start installing.
10. If the environment is installed successfully, the program will show that all requirements are met.
11. Click **Finish** to finish and close the environment setup wizard.

Install **Mech-Eye Viewer**

1. Double-click on Mech-Eye Viewer .exe file to run the Setup Wizard.
2. Click **Next** and select a location to install the software. You can also choose to create a shortcut on the desktop or on the Start menu.
3. Click **Next** and choose the components you want to install (the default one in most cases). Please ensure that there is sufficient storage for software installation.
4. Click **Next** to confirm the installation and wait for installation to complete.

Install **Mech-Vision**

1. Double-click on the Mech-Vision .exe file to run the Setup Wizard.
2. Click **Next** and select a directory location for software installation. You can also choose to create a shortcut on the desktop or on the Start menu, and whether to override the global ini file.
3. Click **Next** to confirm the installation and wait for installation to complete. Please ensure that there is sufficient storage for software installation.

Install **Mech-Viz**

1. Double-click on the Mech-Viz .exe file to run the Setup Wizard.
2. Click **Next** and select a directory location for software installation. You can also choose to create a shortcut on the desktop or on the Start menu, and whether to override the global ini file.
3. Click **Next** to confirm the installation and wait for installation to complete. Please ensure that there is sufficient storage for software installation.

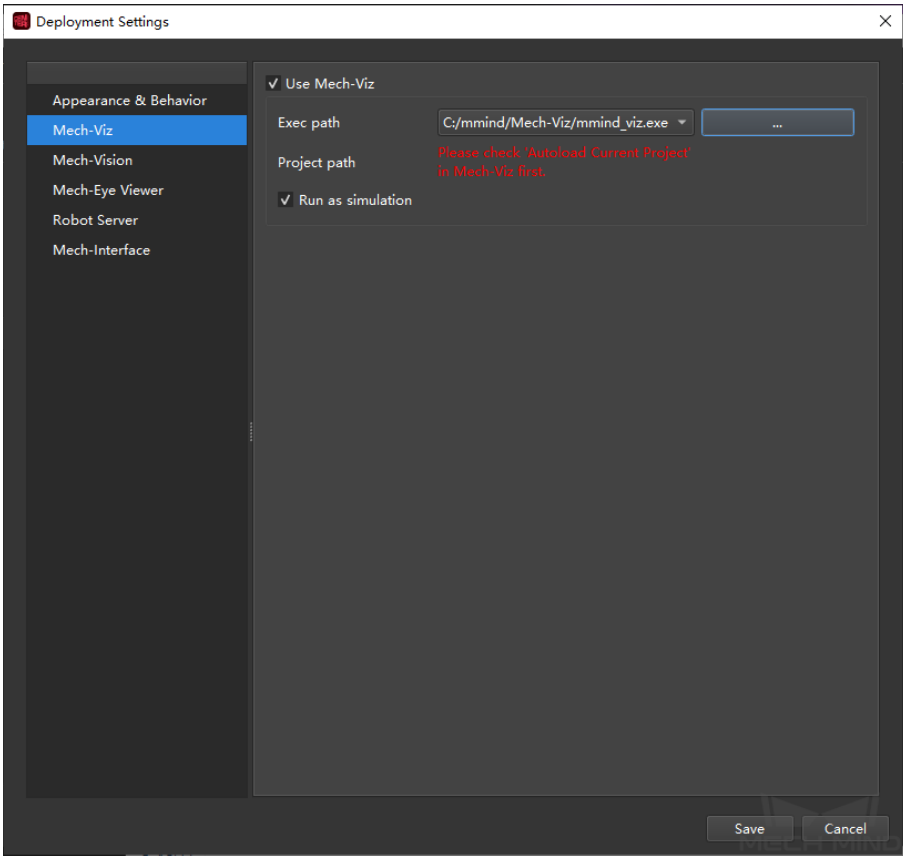
Now you have successfully installed the software and environment. Please read the next section.

4.2 Configure Mech-Center

Mech-Center is the **control center of Mech-Mind Software Suite** independently developed by Mech-Mind Robotics. It implements global setting, status checking, and data transmission of the Mech-Mind Software Suite, and therefore enables users to control the whole robot system.

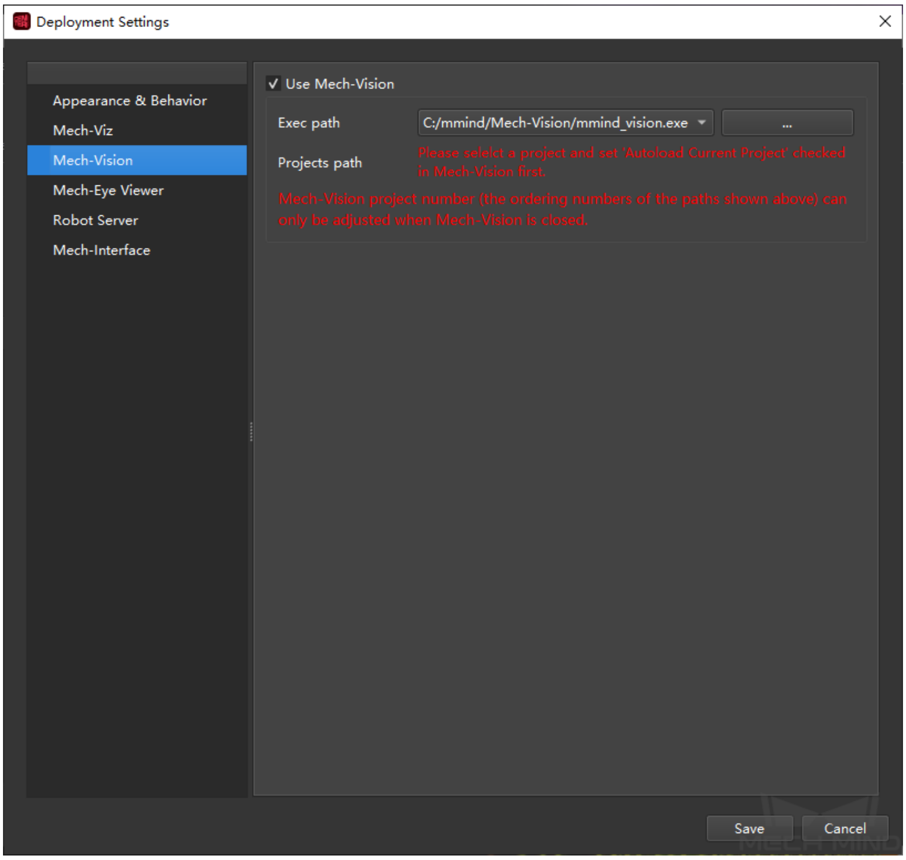
After installing the software successfully, double-click on the icon of Mech-Center to open it. Click on **Deployment Settings** in the upper left corner to start setting. Please follow the steps below to complete the configuration of Mech-Center:

Setting up Mech-Viz



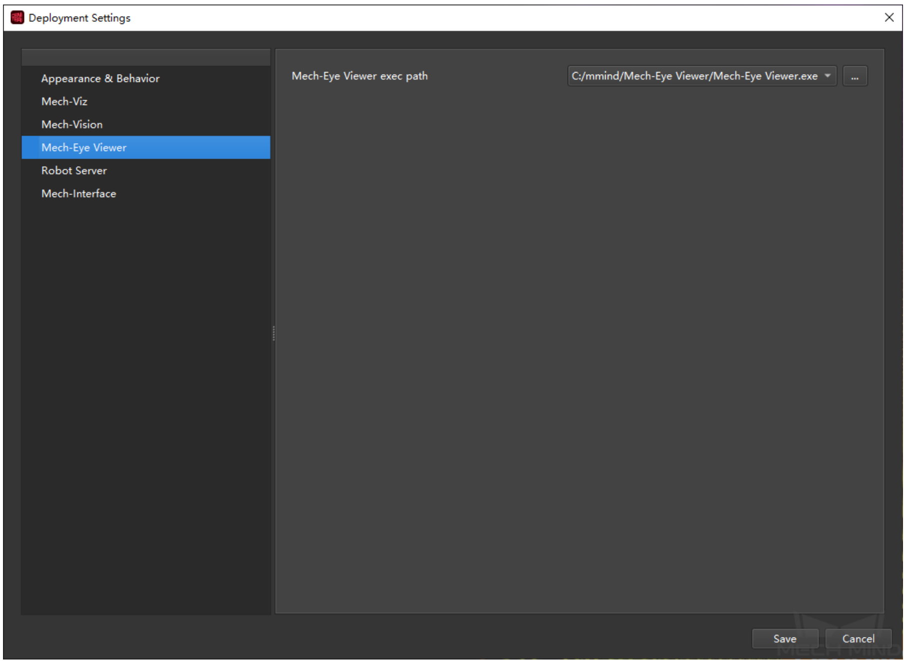
- Click on ⋯ to select the directory location where Mech-Viz .exe file is saved, and then check *Run as simulation*. Click *Save* to finish.
- You can ignore the words in red.
- If *Run as simulation* is checked, clicking *Run* in Mech-Center will only control the robotics simulator in Mech-Viz, or else the real robot will be controlled. Normally, *Run as simulation* is checked during the programming process in Mech-Viz, and it can be unchecked after the programming is completed.

Setting up Mech-Vision



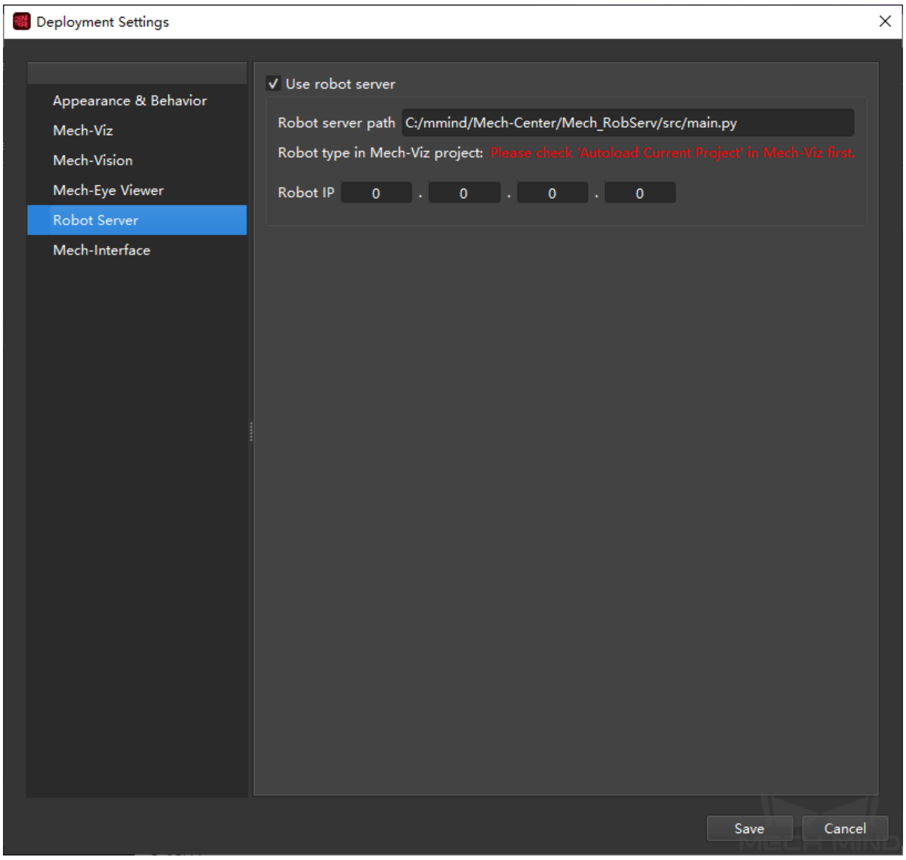
- Click on ··· to select the directory location where Mech-Vision .exe file is saved, and click on *Save* to finish.
- You can ignore the words in red.

Setting up Mech-Eye Viewer



Click on ··· to select the directory location where Mech-Eye Viewer .exe file is saved, and click on *Save* to finish.

Setting up Robot Server



- The directory where the Robot Server is saved has been filled in automatically. Please make sure it ends with .py.
- You can ignore the words in red.
- Enter the robot IP address that has been set before, and then click *Save* to finish.

Now you have completed configuring Mech-Center. Please read the next section.

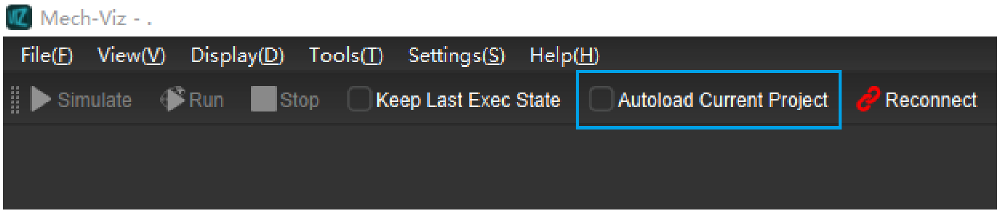
4.3 Add a Robot Model and Connect the Real Robot

In order to connect to a real robot, you need to create a new project in Mech-Viz and add a robot model that corresponds with the real robot.

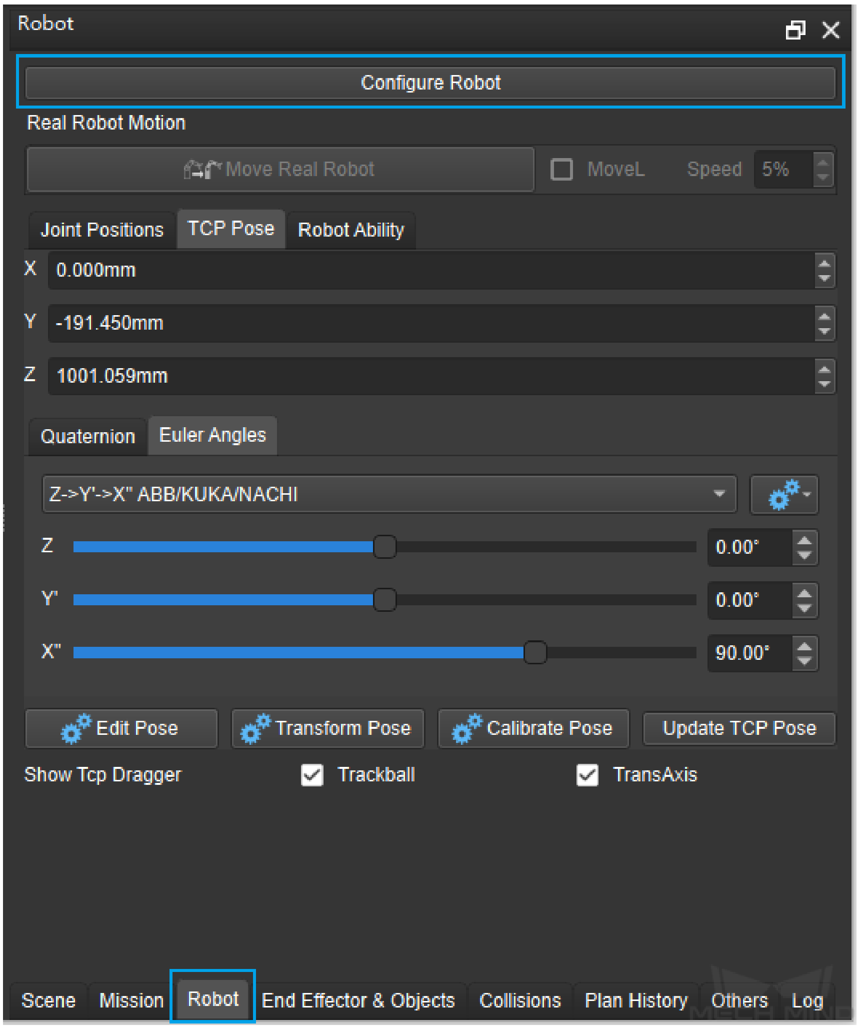
Mech-Viz is a graphical programming software independently developed by Mech-Mind Robotics to control industrial robots. It is capable of robot motion simulation, trajectory planning, collision detection, etc.

1. Add a Robot Model

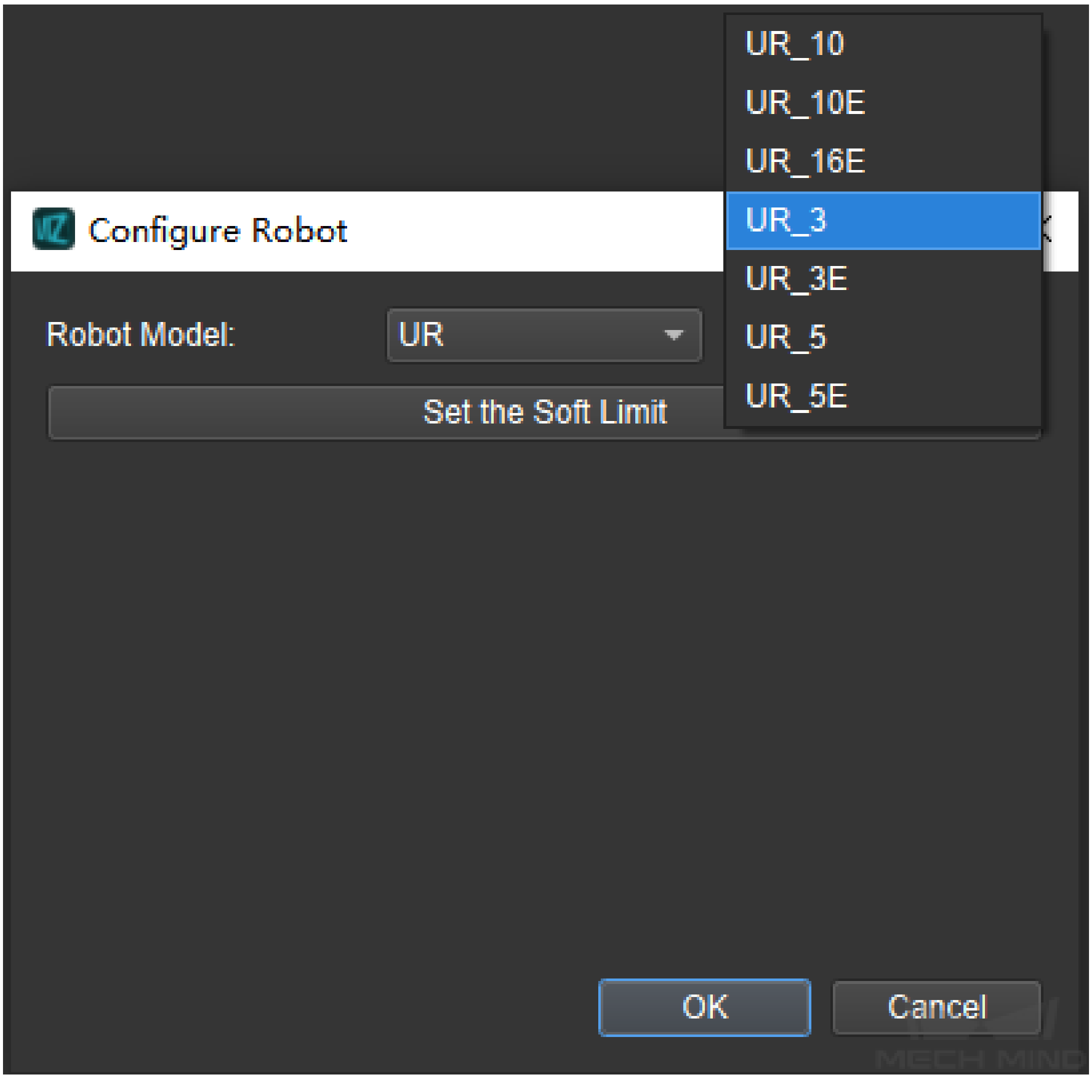
    1. Double-click on the icon of Mech-Viz to open it, and check *Autoload Current Project* on the Navigation bar.



2. Click on the **Robot** tab in the lower right corner, and then click on *Configure Robot* to select a robot model.

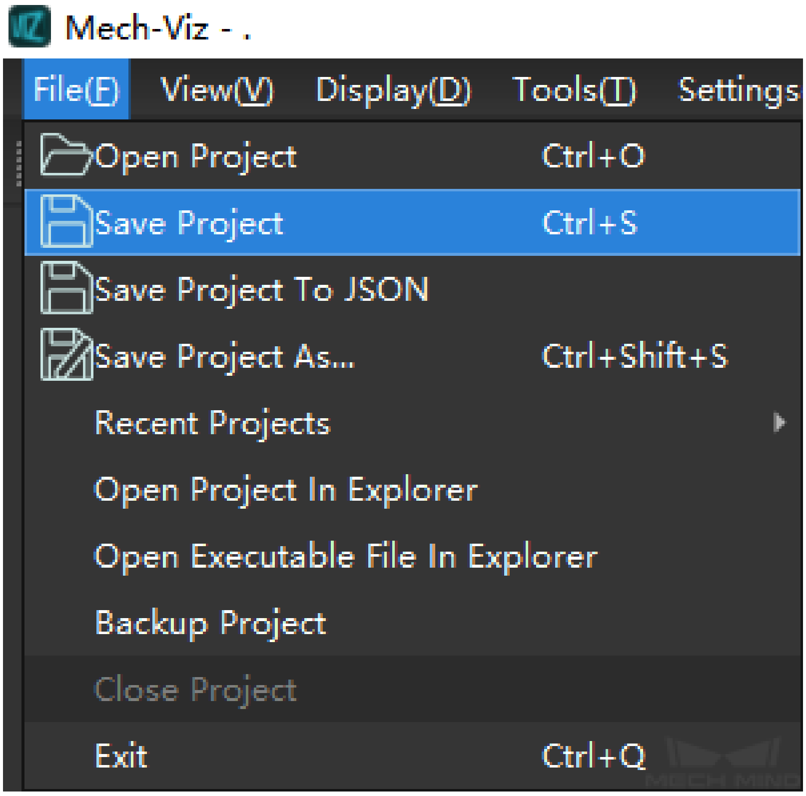


3. In this box palletizing project, a UR_3 will be used, so select *UR_3* and click on *OK*.

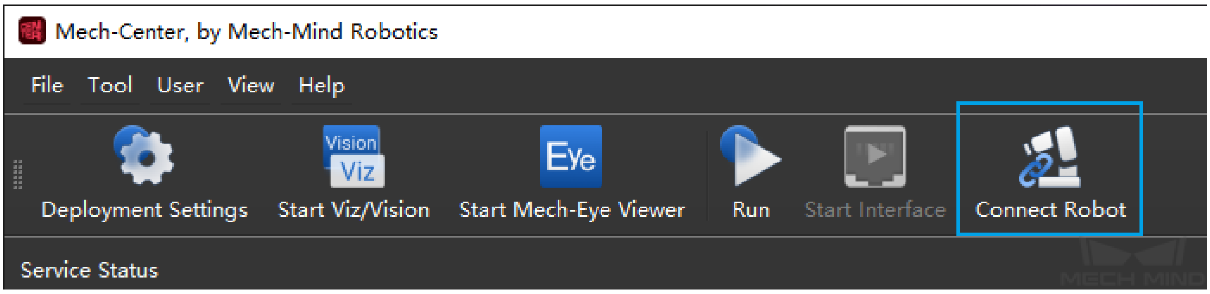


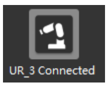
Please select the robot model you are using.

1. Click on *Save Project* in the upper left corner to save the project locally.



2. Connect to a Real Robot
   1. Go back to Mech-Center, and click on *Connect Robot*.



   2. If ** Successfully Connected** is displayed in the Log panel on the right, then the robot is connected successfully. An icon 

will appear in the service status panel as well.

Now you have successfully added a robot model and connected to the real robot. Please read the next section.

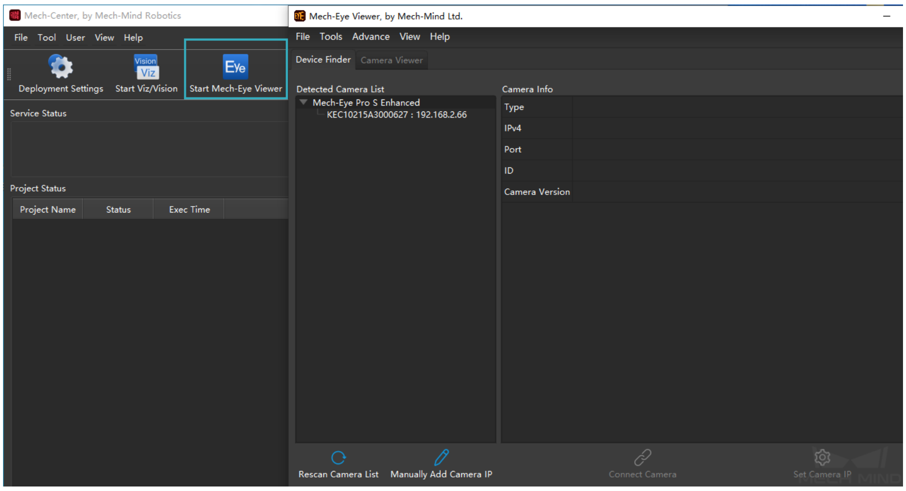
4.4 Connect and Test the Camera

This section will show you how to connect a camera via Mech-Eye Viewer and test if the camera can capture images correctly.

Mech-Eye Viewer is a camera configuration software independently developed by Mech-Mind Robotics. You can use the software to connect to the camera and capture images.

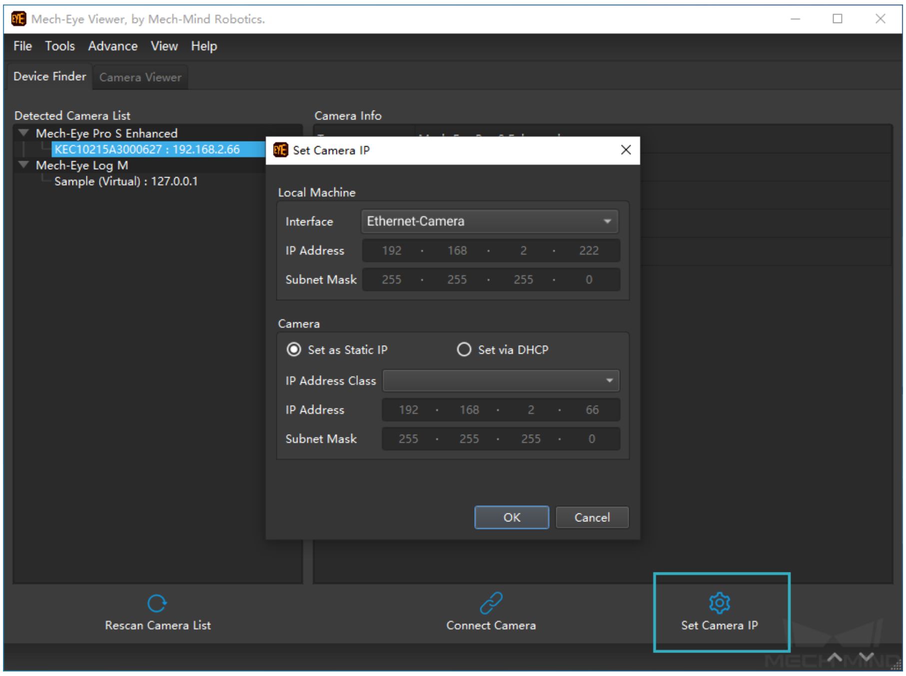
Please follow the steps below to connect to the camera:

1. Click on *Start Mech-Eye Viewer* in Mech-Center.

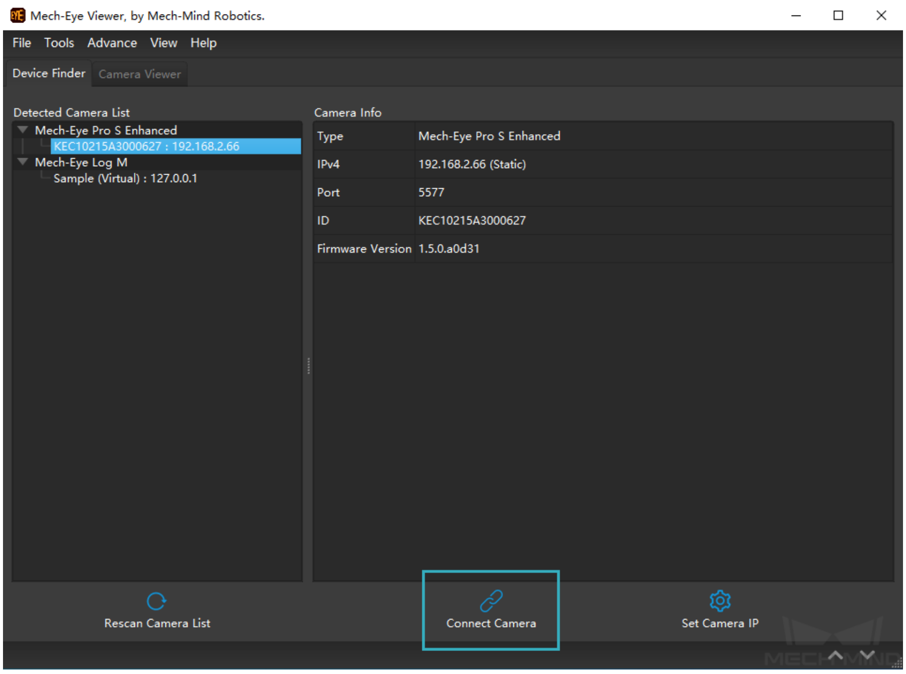


2. Set a static IP address for the camera.

   After selecting the camera to be connected (please do not select the virtual camera with a Virtual tag), click on *Set Camera IP* and select **Set as Static IP** in the pop-up window. Since the IP address of the IPC is 192.168.2.222, set the IP address of the camera as 192.168.2.66. Click on *OK* to save the IP address.

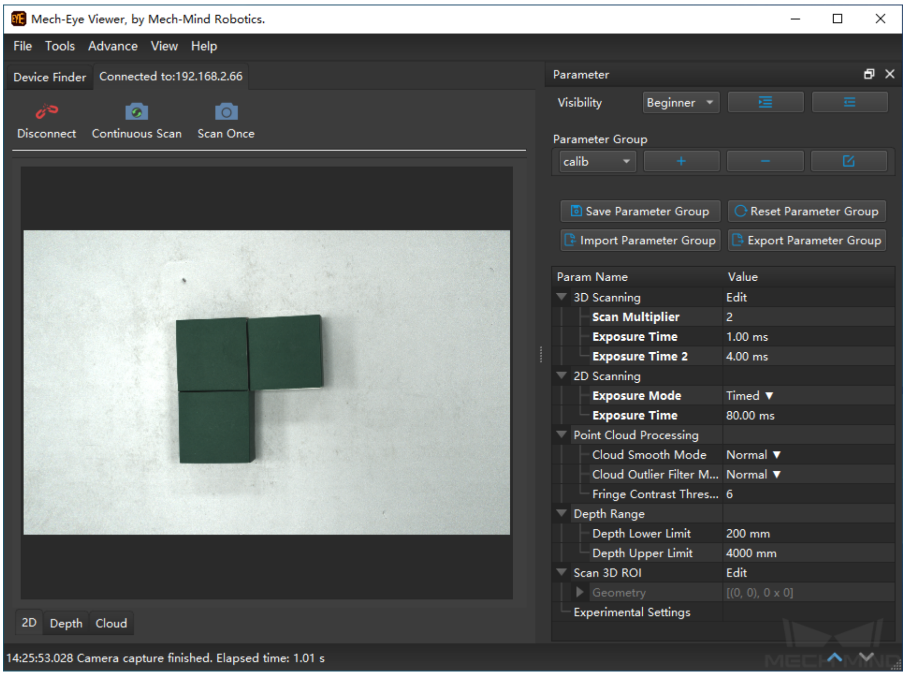


3. You can either double-click the camera IP on the left or click on the camera IP and then click on *Connect Camera* in the bottom center to connect the camera.



4. After connecting successfully, you will enter the camera viewer interface.

   Click on *Continuous Scan* to keep capturing images , and click *Scan Once* to capture one image at a time.

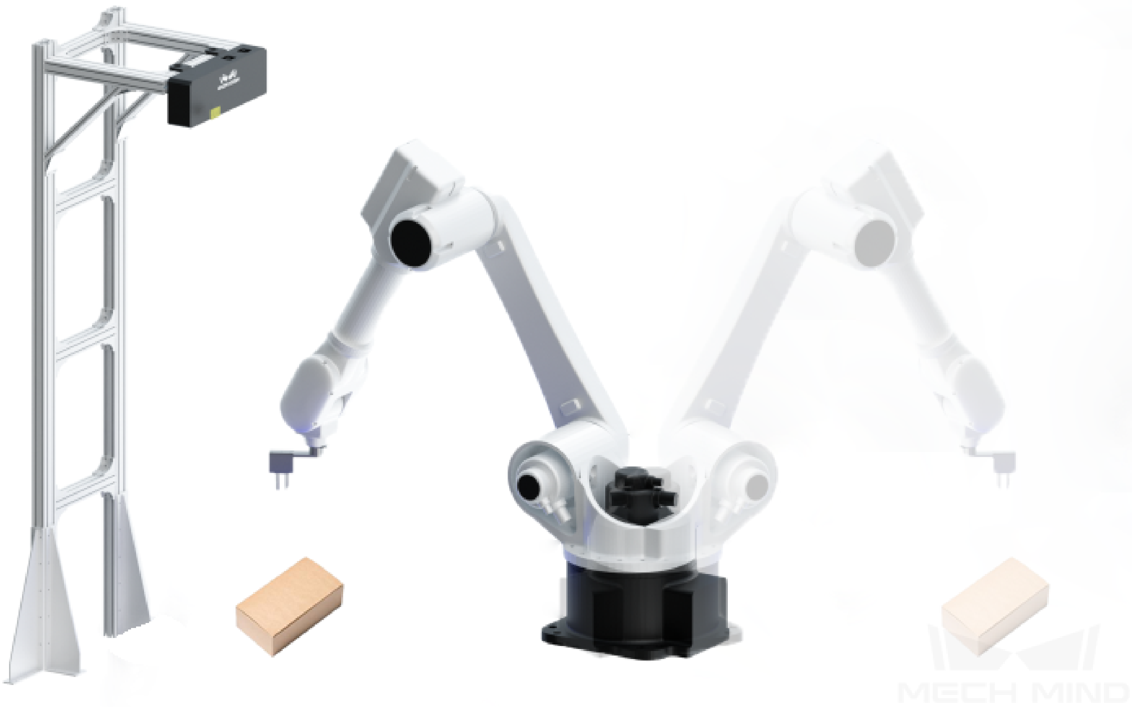


If the camera can capture images correctly, click on *Stop*. Now you have successfully connected and tested the camera. Please read the next section.

CHAPTER

FIVE

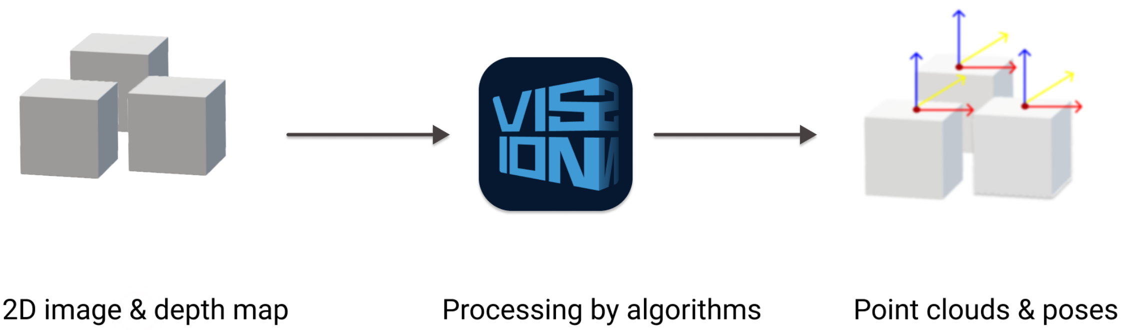
YOUR FIRST PICK



Before reading this section, please make sure you have completed the configurations in the previous sections of this chapter.

In this section, you will use the Mech-Mind Software Suite to obtain the pose of a box, simulate the robot’s trajectory, and let the physical robot complete picking and placing of the box.

5.1 Use Mech-Vision to Obtain the Box Pose



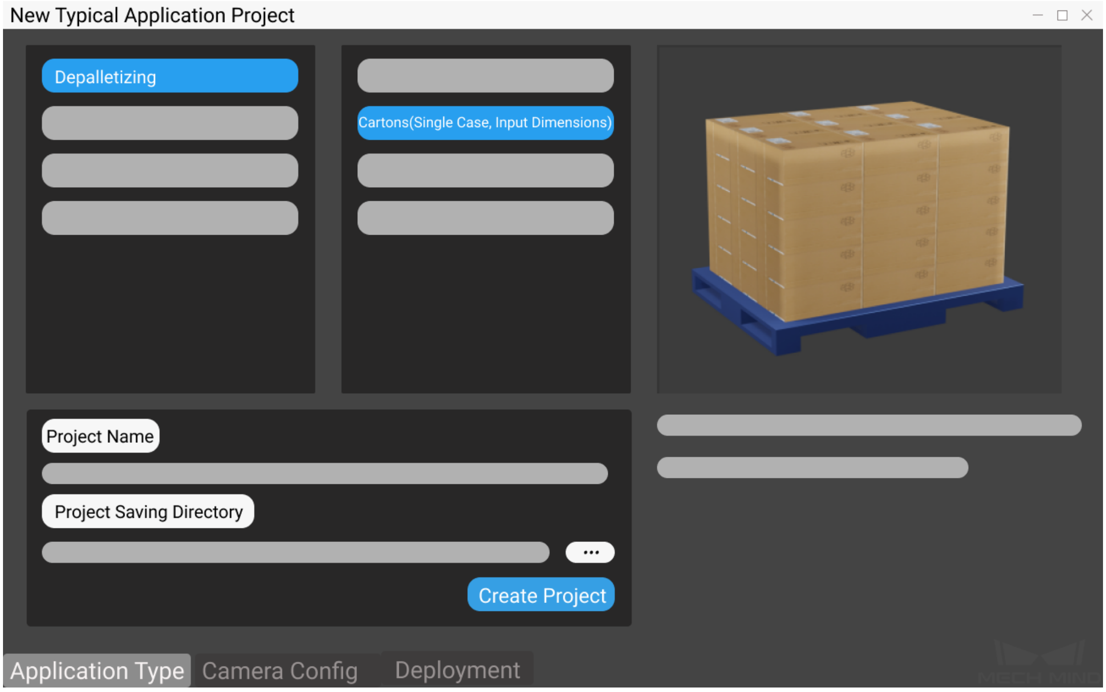
In this section, you will learn how to use Mech-Vision to obtain the pose of a box.

Preparation

1. Get two boxes of the same dimensions and record the dimensions (length, width, and height).
2. Get a calibration board provided by Mech-Mind Robotics (please make sure the dots on the calibration board are clear and free of obvious scratches, and the calibration board does not have deformation).

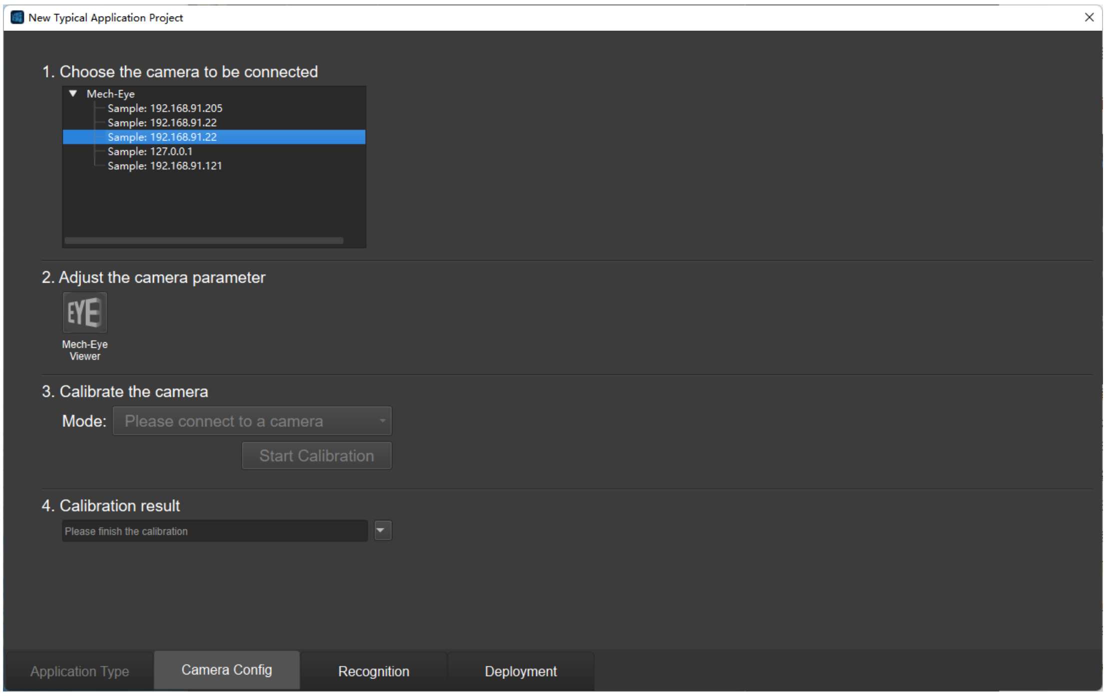
1. Create a new project via New Typical Application Project.

Open Mech-Vision, and click on *Typical Applications* → *New Typical Application Project* in the menubar on the top. After the window New Typical Application Project pops up, select *Depalletizing* → *Boxes (Single Case)*, and set the project name and file location to finish creating the project.



2. Complete camera configuration and calibration.

Please follow the instructions on the page to complete the following steps:



1. Select the camera to connect:

   Double-click the camera to be connected in the camera list to create a connection with the real camera. After the connection is established, the interface of the remaining steps will be activated.

2. Adjust camera parameters:

   Select the default parameter group built into the Mech-Eye Viewer.

3. Calibrate the camera:

   First mount the calibration board to the end of the robot arm.

   Click on *Start calibration* and follow the step-by-step instructions in calibration_guide to complete the calibration.

   After the calibration is completed, remove the calibration plate and mount the end effector.

4. Calibration result:

   Load the calibration results from the previous step to finish all the steps on the camera configuration page.

   Click *Recognition* at the bottom of the interface to go to the next step.

3. Set the parameters related to object recognition.

Please place the carton in the center of the camera's field of view in a random orientation before proceeding, as shown in the figure below.

Attention: Please Make sure that only the target object to be recognized is in the camera' s field of view, which you can confirm by capturing images in Mech-Eye.

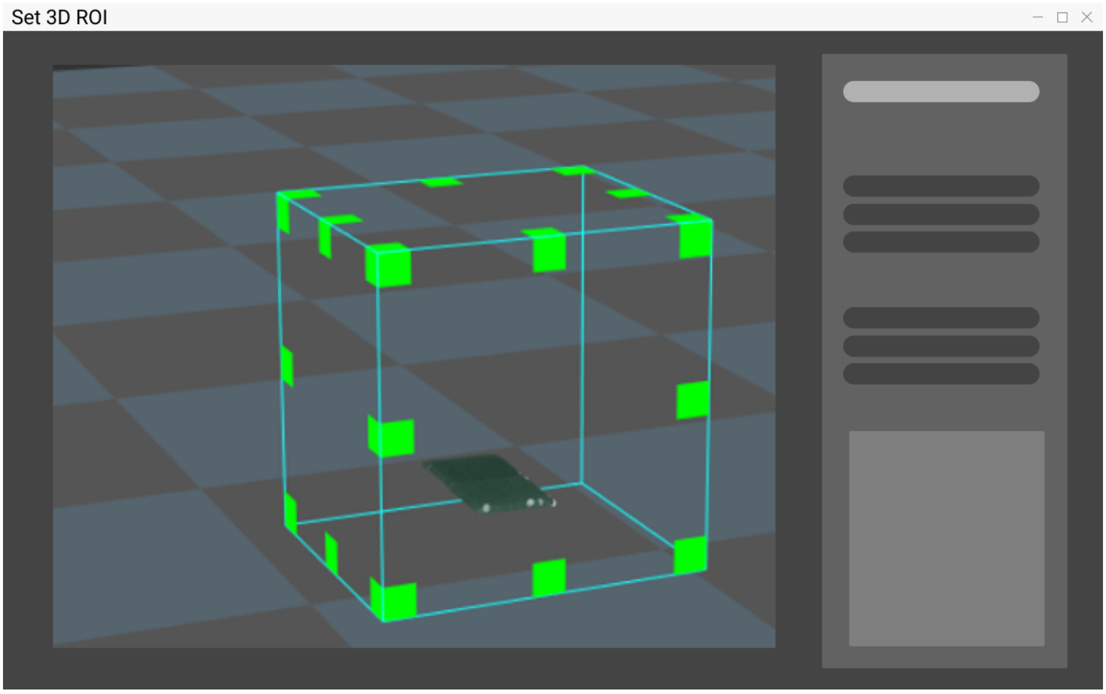
1. Box dimensions:

   Fill in the box dimensions in the field of box dimensions on the right side of the interface. The model path and configuration file path are preset by the software, and you do not need to change them.

2. 3D ROI:

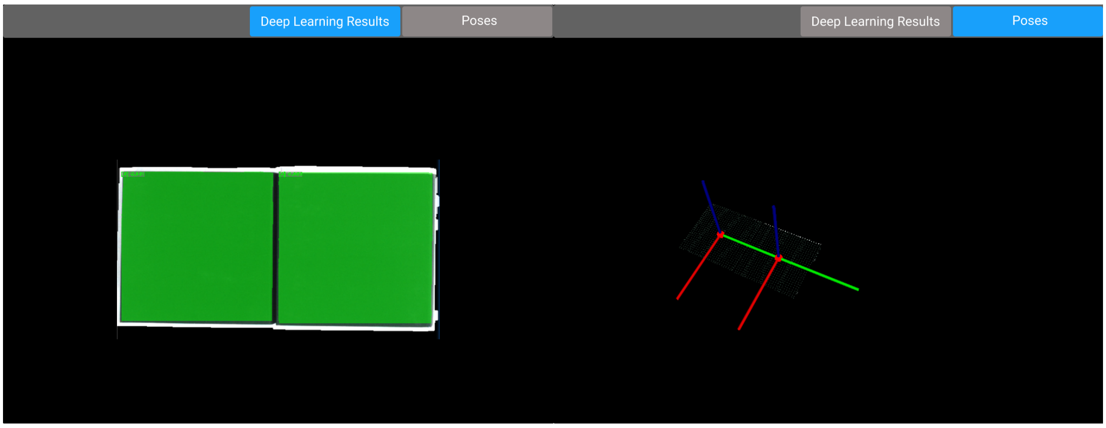
   Click on *3D ROI* in the upper left corner of the window to open the window of setting the ROI (region of interest) and complete the ROI settings. Press Ctrl and left-click on the little green squares on the edge of the cube that represents the ROI to adjust the ROI.

   Attention: The cube representing the ROI should contain all the objects to recognize. The cube walls should not go through the object point clouds.



3. Deep learning results & poses:

   After you click on *Generate pose*, the project starts running and outputs the deep learning results and object poses, as shown below.



If there are X, Y, and Z coordinates marked on a box, the box has its pose output from the project.

When going through this step, if the two boxes are not segmented in the deep learning results or no pose is output, please try the following measures to solve the issue.

- Confirm whether the box dimensions filled in are the same as the actual dimensions.
- Re-set the 3D ROI.
- Adjust the parameters of the camera.

Click on **Deploy** at the bottom of the interface to proceed to the next step.

4. Complete the deployment and view the final running result.

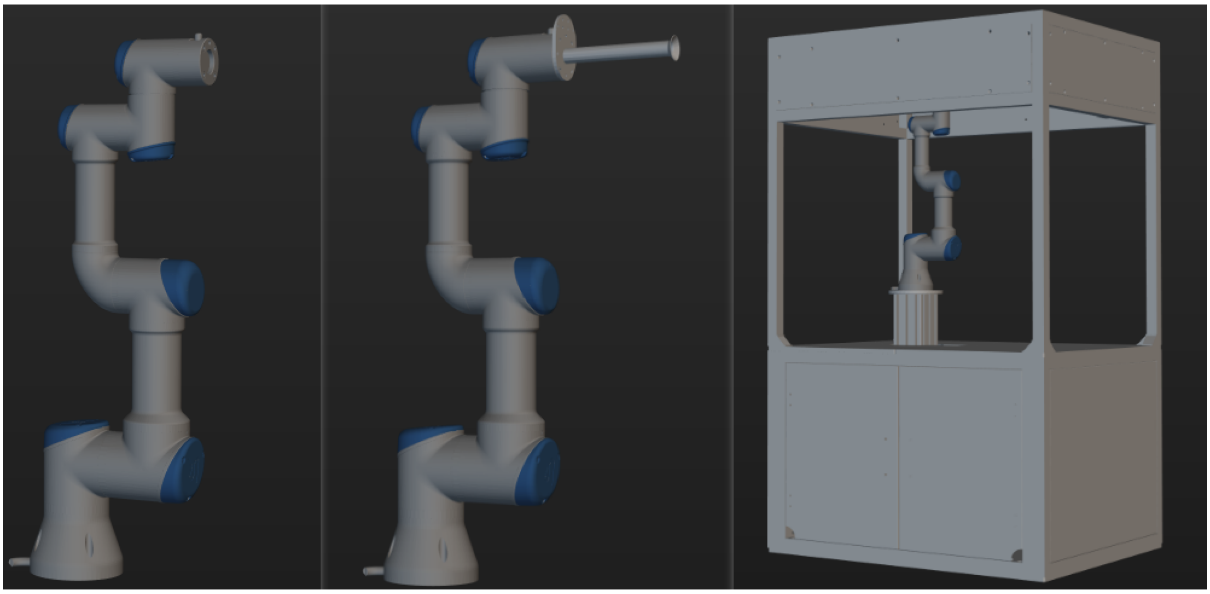
At this point, you have completed all the settings of the project. Please click on *Finish* to finish deploying the project and enter the custom editing mode.

You have done everything needed in Mech-Vision, please proceed to the next section.

5.2 Use Mech-Viz to Plan a Motion Trajectory for the Robot

In this section, you will learn how to use Mech-Viz to plan robot's trajectory. Please open Mech-Viz.

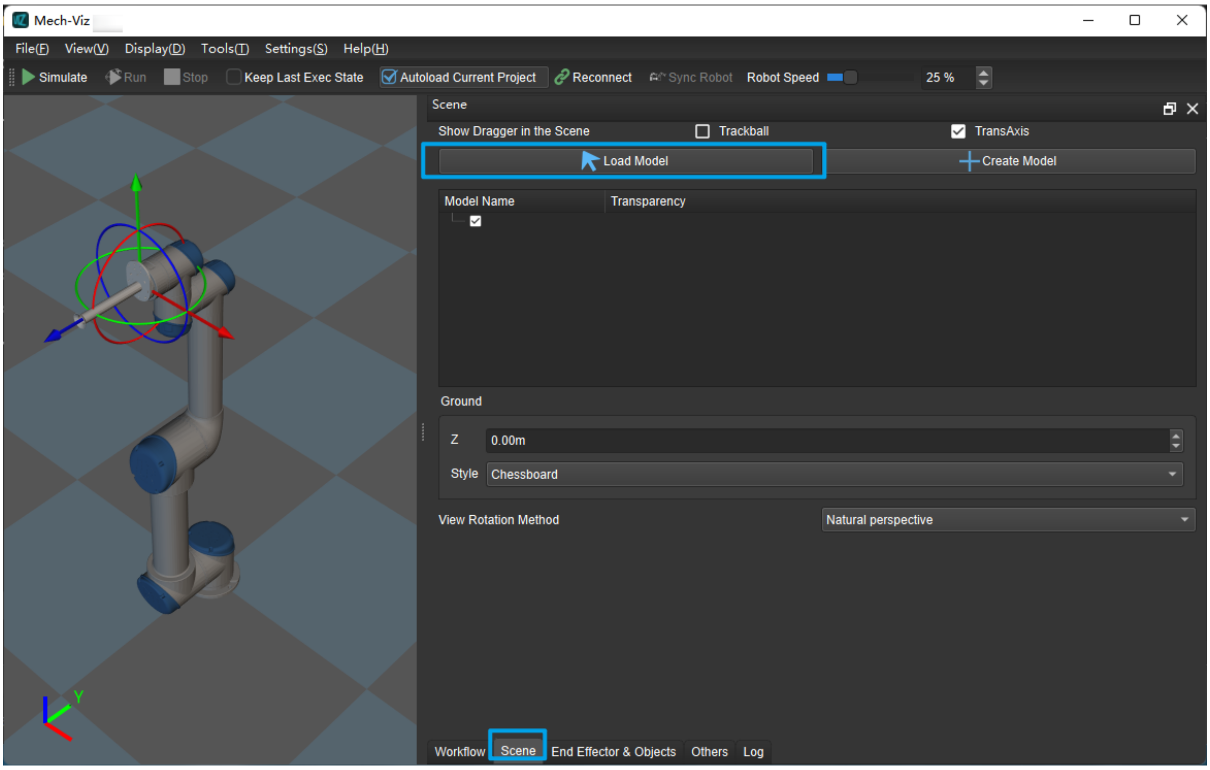
5.2.1 Add Scene and End Effector Models



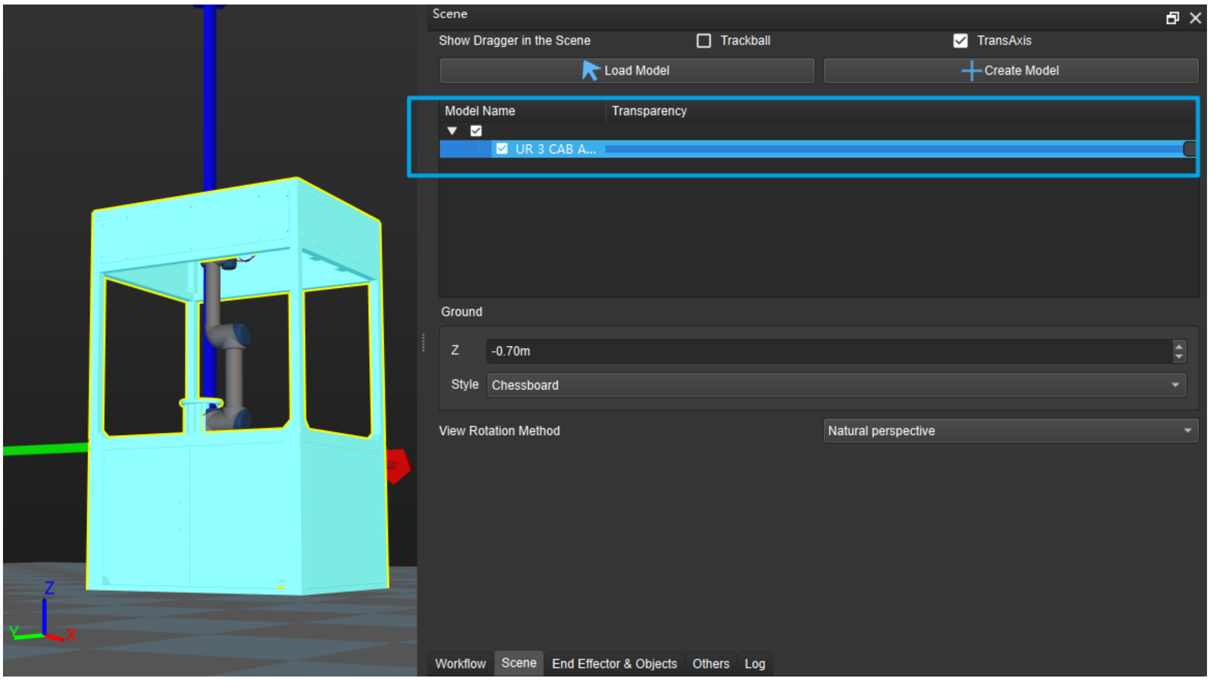
Original   Add an end effector model   Add scene models

1. Add the scene models.

The scene models usually make up the 3D model of the robot's workstation.

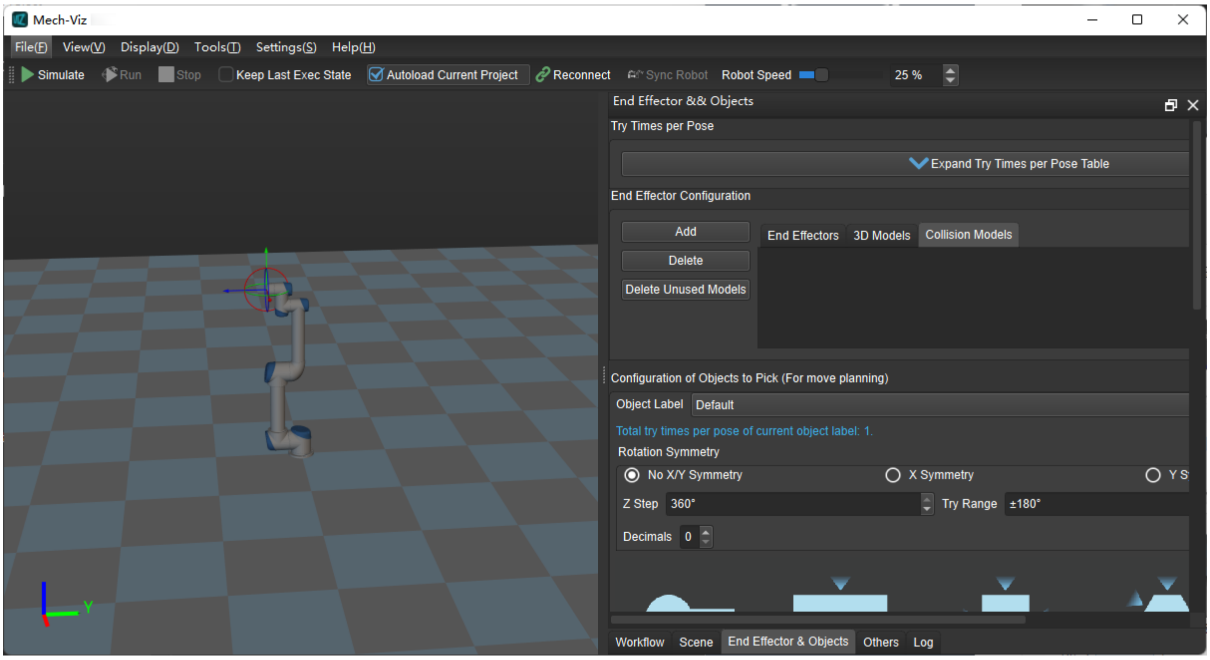


- After loading the models, you need to adjust *Floor* → *Z* to fit the scene models to the floor.
- To facilitate the planning of subsequent trajectories, so that the scene models do not block the robot model, you can reduce the transparency of the scene model by dragging the slider, and restore the default settings after the trajectory planning is completed.



2. Add a model for collision detection.

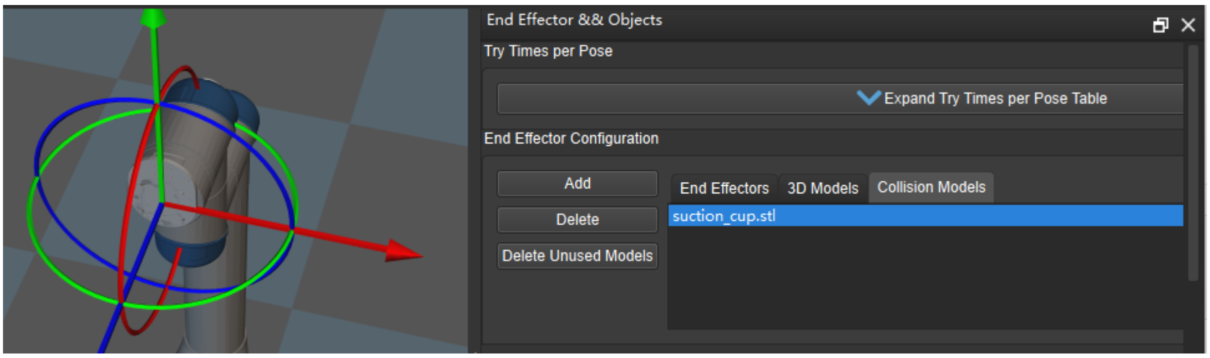
Below are the instructions for adding a model for collision detection.



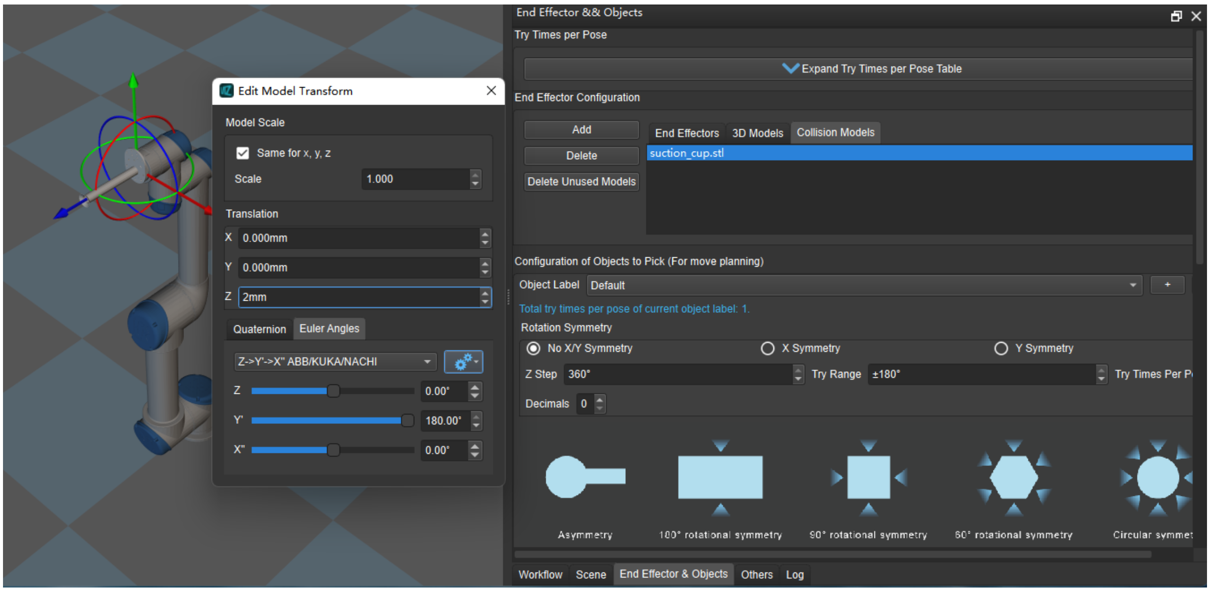
1. Select the tab **End Effector & Objects** at the bottom.
2. Click on *Collision Models*.
3. Click on *Add*.
4. Select the model you want to load.
5. Click on *Open*.

3. Edit model transformation.

Click on the loaded collision model to view its positional status in the simulation. As shown below, the model is obviously in the wrong position.

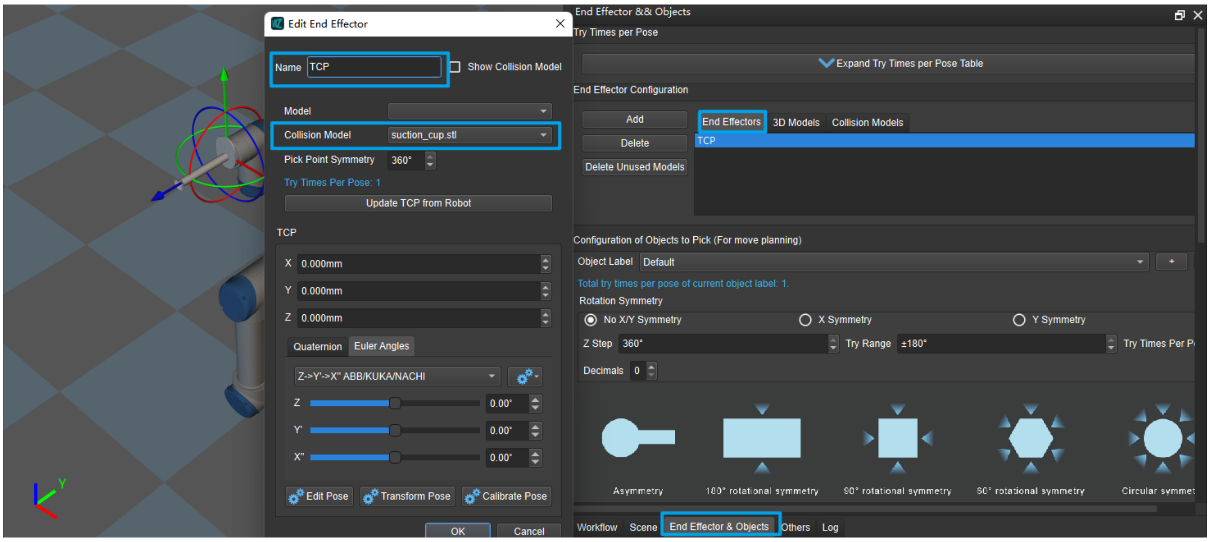


Double-click on the model and open the window for editing the model. By adjusting the parameters under **Object Pose**, you can put the model into a correct position, as shown below.



4. Add an end effector.

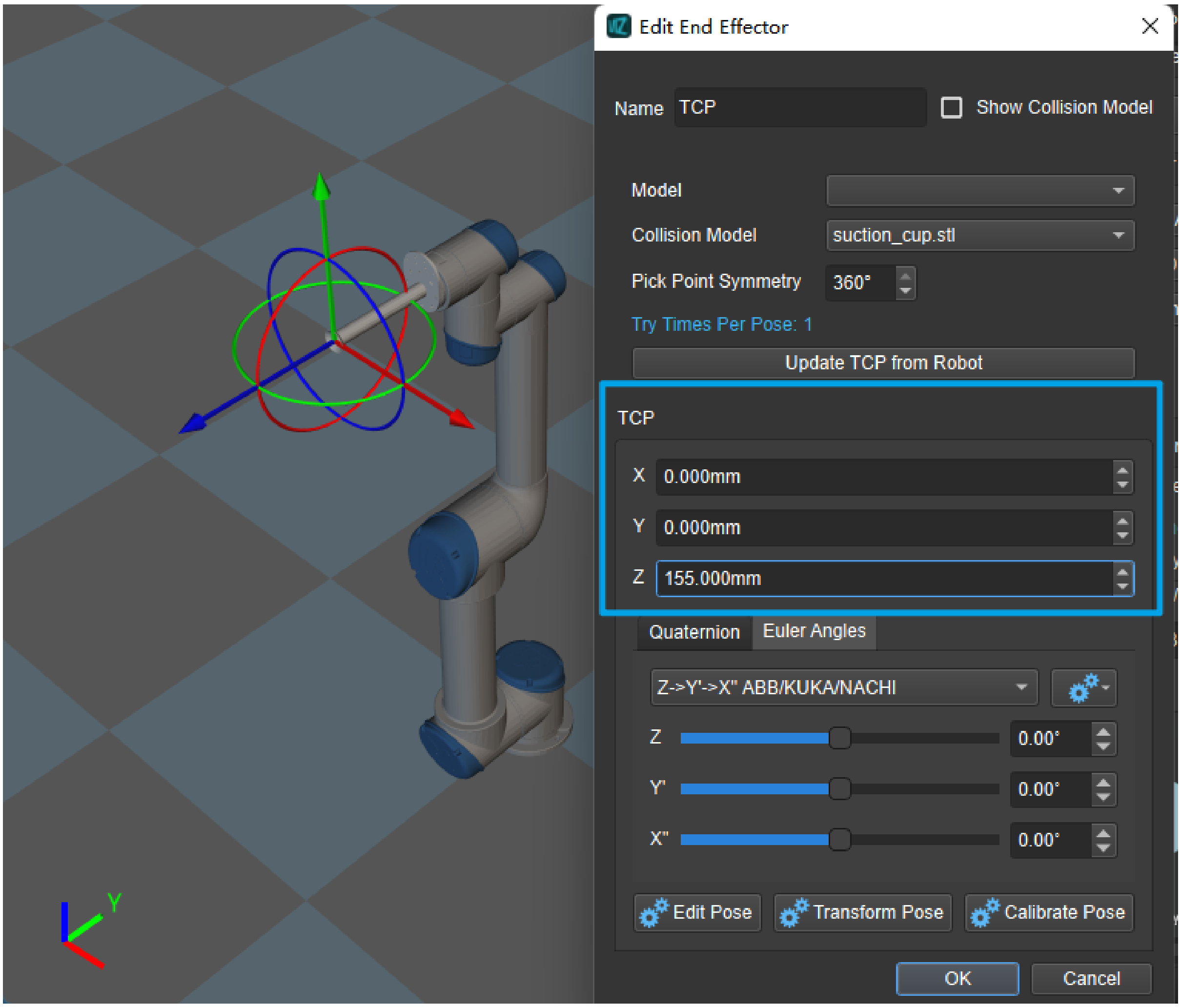
The model of the end effector is the model of the gripper you mount on the end of the robot's arm.



1. Click on the tab **End Effector & Objects** tab at the bottom;
2. Click on *end effector*;
3. Click on *Add*;
4. Select the collision model loaded in the previous step;
5. Enter a custom end effector name.
6. Click on *OK* .

5. Adjust the tool center point.

The tool center point is represented by the center of the dragger (the coordinate sphere at the end of the robot model).



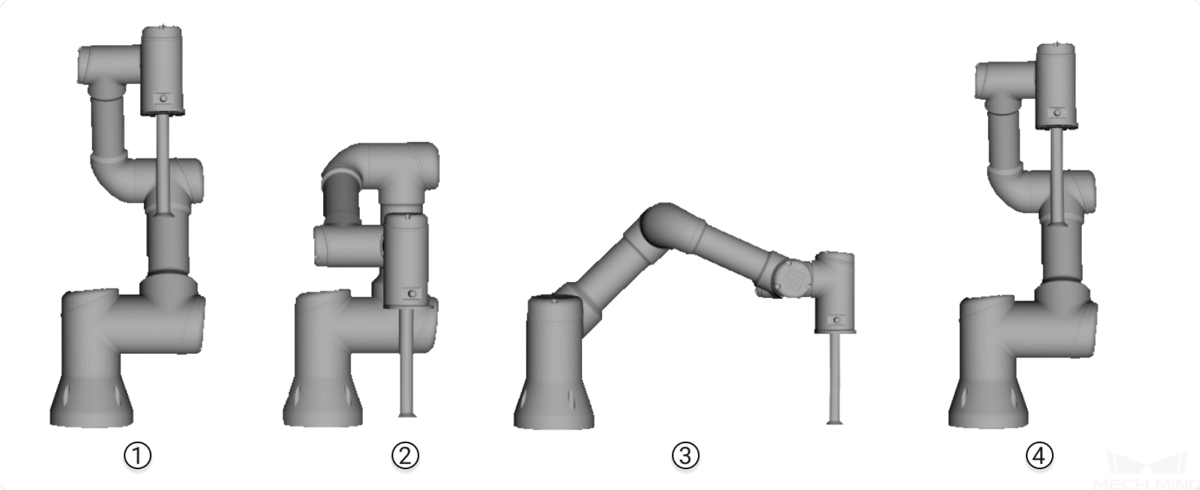
1. Double-click on the name of the end effector added in the previous step.
2. Modify the parameters under TCP, and adjust the tool center point to the end of the end effector.
3. Click *OK* to complete the setup.

At this point, you have completed the model related settings, please proceed to the next section.

5.2.2 Plan Motion Trajectory

The planning of motion trajectories is done in the **Workflow** panel. Drag a task from the skill list to the workspace in the middle and set the corresponding task parameter in the parameter panel on the right, and in the end, connect the tasks to implement the designed program functions.

In this example, you only need to implement simple picking and placing, and you can plan the motion trajectory as follows.

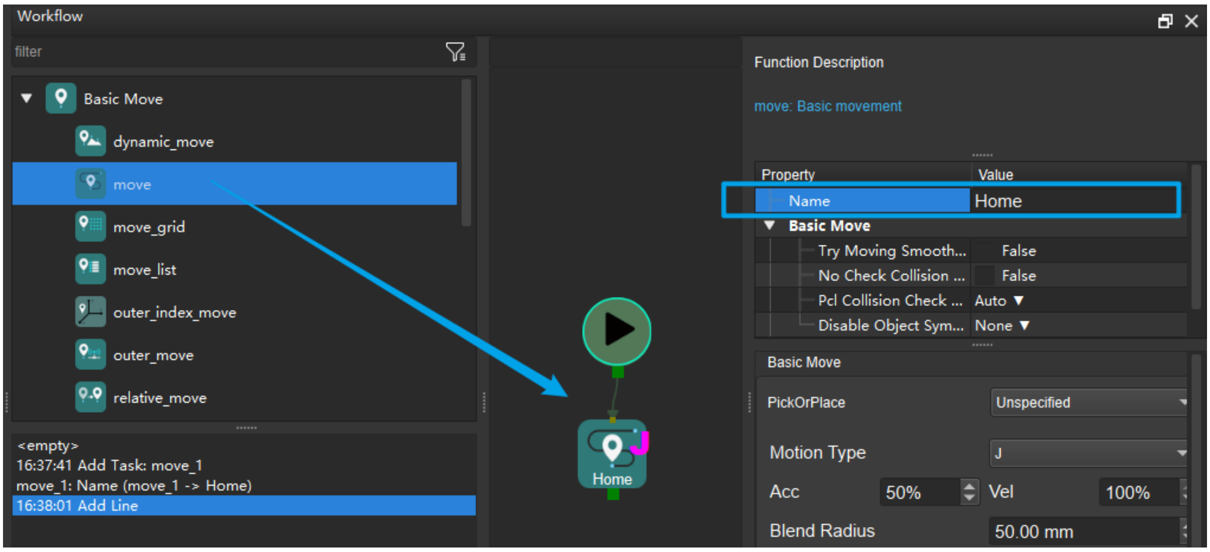


1. Set the Home point.

The Home point is the starting point of the robot's motion trajectory, and it is a safe position. At this point, the robot should be away from the objects to pick and surrounding devices and should not block the camera's field of view.

You can use a move task to set a target pose in the robot's motion trajectory and the way to move to the pose. In the task, you can simulate any pose within the robot's range of motion. Therefore, you can use move to set the Home point.

1. Click on *Sync Robot* on the toolbar, and the pose of the robot model will be synchronized with that of the real robot.
2. Use the teach pendant to move the real robot to the Home point you define.
3. Find *Workflow* → *Basic Move* → *Move*, and drag it to the workspace. **This Move task will record the current pose of the robot**.
4. Rename the task as Home.



2. Set the pick point.

The pick point should be the pose of the object to pick. So, you need to use tasks visual_look and visual_move to set the pick point.

- visual_look is for triggering the Mech-Vision project and letting the project send the vision recognition result and point cloud to Mech-Viz.
- visual_move is for moving the robot based on the vision recognition result.

  Find *Workflow* → *Vision* → *visual_look, visual_look* and drag them to the workspace.

  Parameter setting: Click on *Get Vision Services*, select the Mech-Vision project created before in the drop-down list of service names.

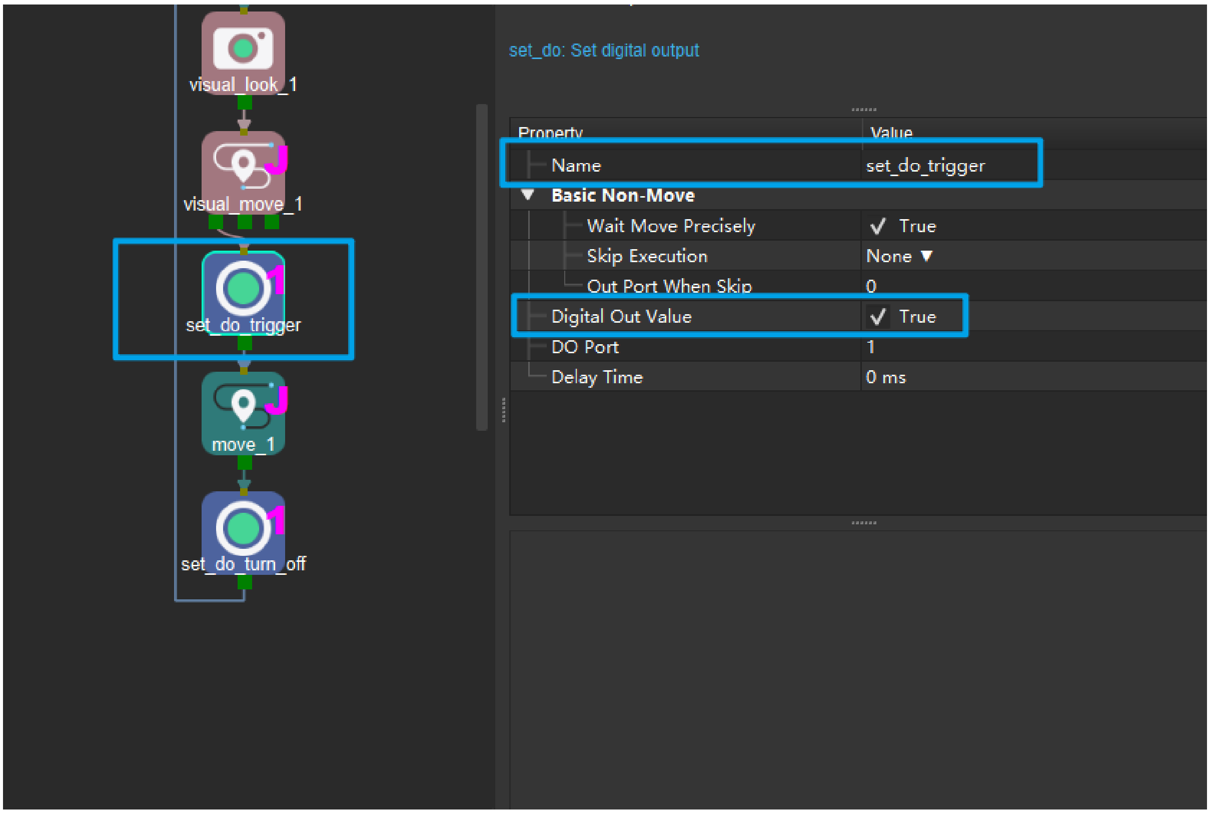
After the robot reaches the picking pose, it triggers the suction cup to pick the object (the end effector is the suction cup in this example).

- Use set_do to set the specified robot port signal to control the end effector.

  Find *Workflow* → *DI/DO* → *set_do*, drag it to the workspace.

  Parameter setting:

  1. Change the task’s name to “set DO_ON”;
  2. Set the DO value to True (when set to True, Mech-Viz will send a control signal to trigger the suction cup).



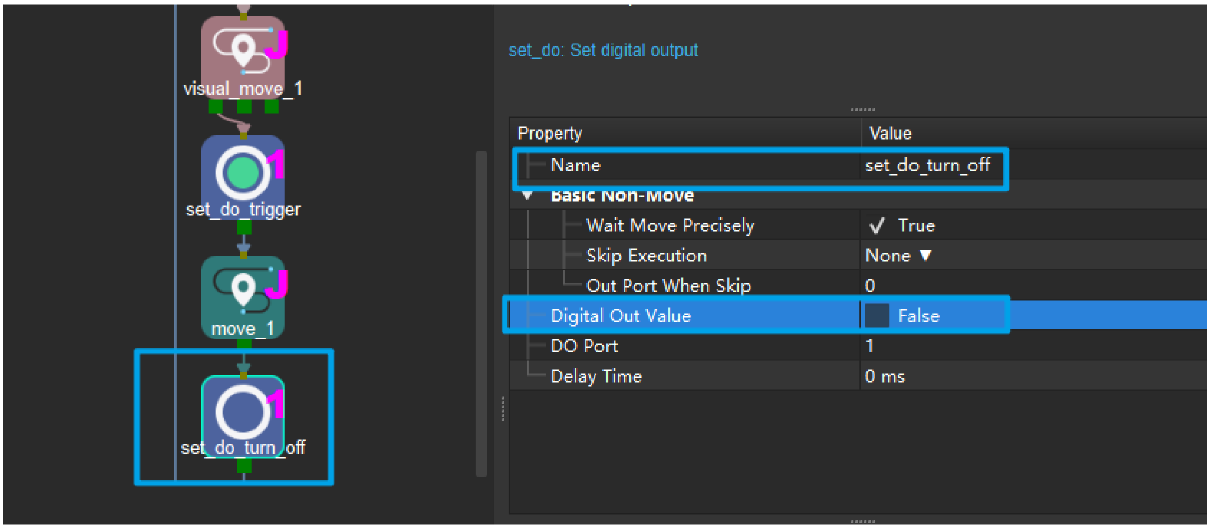
3. Set the placing point.

After the robot picks the object, it needs to move to a placing point you define and release the object.

> Use the teach pedant to let the real robot move to a placing point you define. Then, you can drag a move task to the workspace to record the robot' s pose.

When the robot moves to the placing point, it needs to turn off the suction cup to release the object.

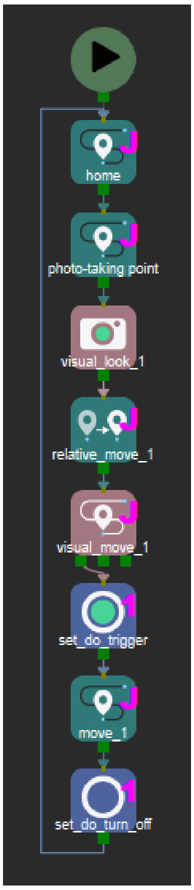
> Find *Workflow* → *DI/DO* → *set_do*, drag it to the project editing area.
>
> Parameter setting:
>
> 1. Rename the task as set_do_off.
> 2. Set the DO value to False (when set to False, Mech-Viz will send a control signal to turn off the suction cup).



4. Return to the Home point.

After releasing the object, the robot needs to return to the Home point.

Please connect the exit port of the task from the previous to the head port of the move task added when adding the Home point.



5. Simulate.

Hint: In the workspace, right-click and get the drop-down menu, and click on *Format* to align the tasks.

Click on *Simulate* to start simulating the motion trajectory of the robot.

Although the task built is logically correct, you can still find the following problems during actual simulations:

1. From the Home point to the pick point, the robot displays a large continuous movement range.
2. Moving to the next point immediately after sending the signal of triggering or turning off the suction cup makes it difficult for the robot to correctly perform picking and placing.
3. The robot can only pick or place an object by moving vertically above the object.

Please proceed to the next section to learn about how to optimize the robot's motion trajectory.

5.2.3 Optimize Motion Trajectory

This section describes how to optimize the robot's trajectory through the following steps to make the trajectory more efficient.

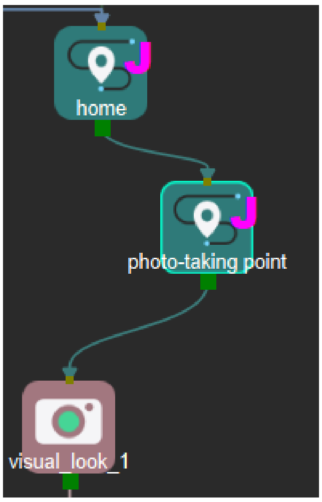
1. Add a **photo-taking point**.

Add a **photo-taking** point between the Home point and the picking point.

Use the teach pedant to let the robot move to a point to facilitate photo-taking.

Hint: Please note that at the photo-taking point, the robot cannot block the camera's field of view. You can use Mech-Eye Viewer to capture images and check if the robot blocks the field of view.

Add a move task to record the current pose of the robot, and set the task's name to **photo-taking point**.



2. Add a **relative move point**.

A reasonable movement for picking should be that the suction cup moves vertically down to the pick point, holds the object, and moves vertically up.

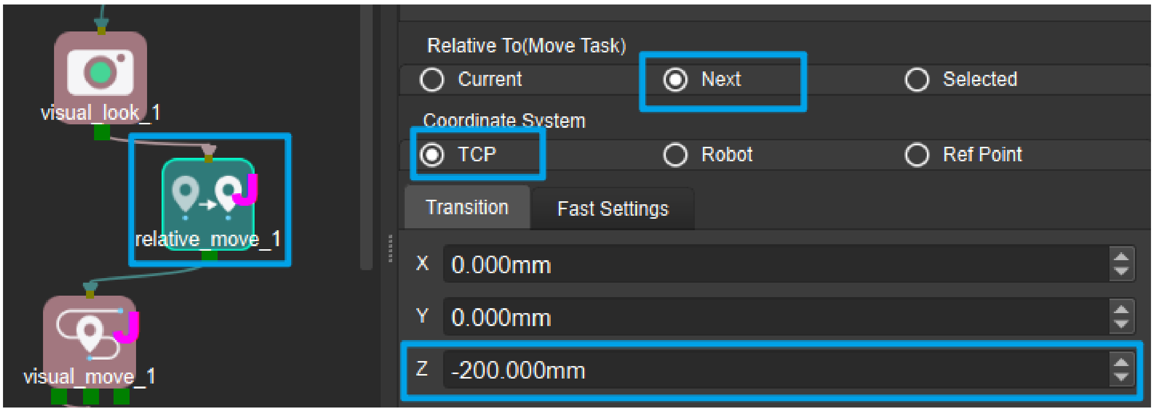
You can use a relative_move task for this purpose.

1. The suction cup moves vertically downward from 200 mm from the pick point in the Z direction.

   Find: *Workflow* → *Basic Move* → *relative_move* and drag it to the workspace.

   Parameter setting:

   1. Under Relative To (Move Task), select **Next**.
   2. Under Transition, set the value of Z to -200.
   3. Keep the default value for the rest of the settings.

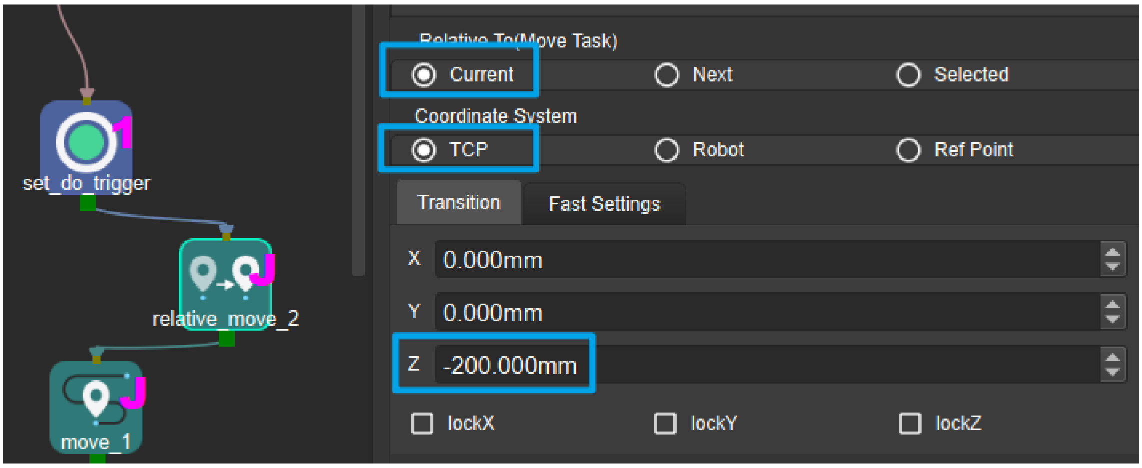


2. The suction cup moves vertically upward for 200 mm after picking up the object.

   Find *Workflow* → *Basic Move* → *relative_move*, drag it to the workspace.

   Parameter setting:

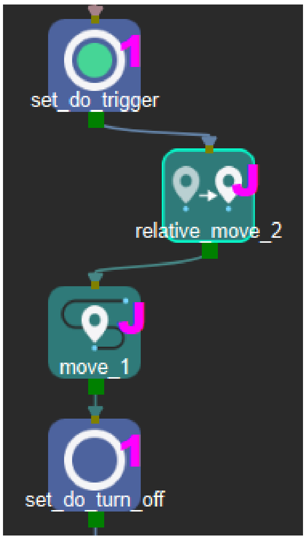
   1. Under Relative To (Move Task), select **Current**.
   2. Under Transition, set the value of Z to -200.
   3. Keep the default value for the rest of the settings.



3. Add a **placing relative move point**.

Add two relative move tasks.

1. The suction cup moves vertically downward from 200 mm up from the placing point.
   1. Under Relative To (Move Task), select **Next**.
   2. Under Transition, set the value of Z to -200.
   3. Keep the default value for the rest of the settings.
2. After the suction cup releases the object, it moves vertically upward for 200 mm.
   1. Under Relative To (Move Task), select **Current**.
   2. Under Transition, set the value of Z to -200.
   3. Keep the default value for the rest of the settings.

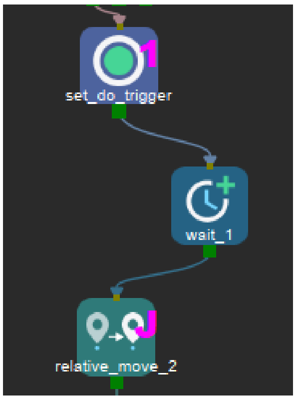


4. Add a **wait** task for picking and placing.

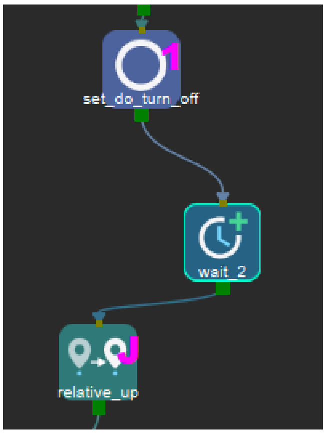
1. After the suction cup touches the object, the program needs to wait for a little while for the suction cup to firmly hold the object.

   Use a wait task to make the robot wait for a specified time. The unit is ms.

   Find *Workflow* → *Tools* → *wait*, drag it to the workspace, and keep the default parameter settings.



2. After the suction cup is turned off to release the object, the program needs to wait for a while to let the suction cup to fully release the object.



5. Simulate

Click on *Simulate* to start simulating the motion trajectory of the robot.

In the simulation this time, you can find that the trajectory is more reasonable. Please proceed to the next section.

5.3 Use Mech-Center to Control a Real Robot to Pick

So far, you have successfully obtained the box poses and successfully simulated the picking and placing of a box. Now you can try running the real robot to physically implement the picking and placing for the first time.

1. Adjust the robot' s speed.

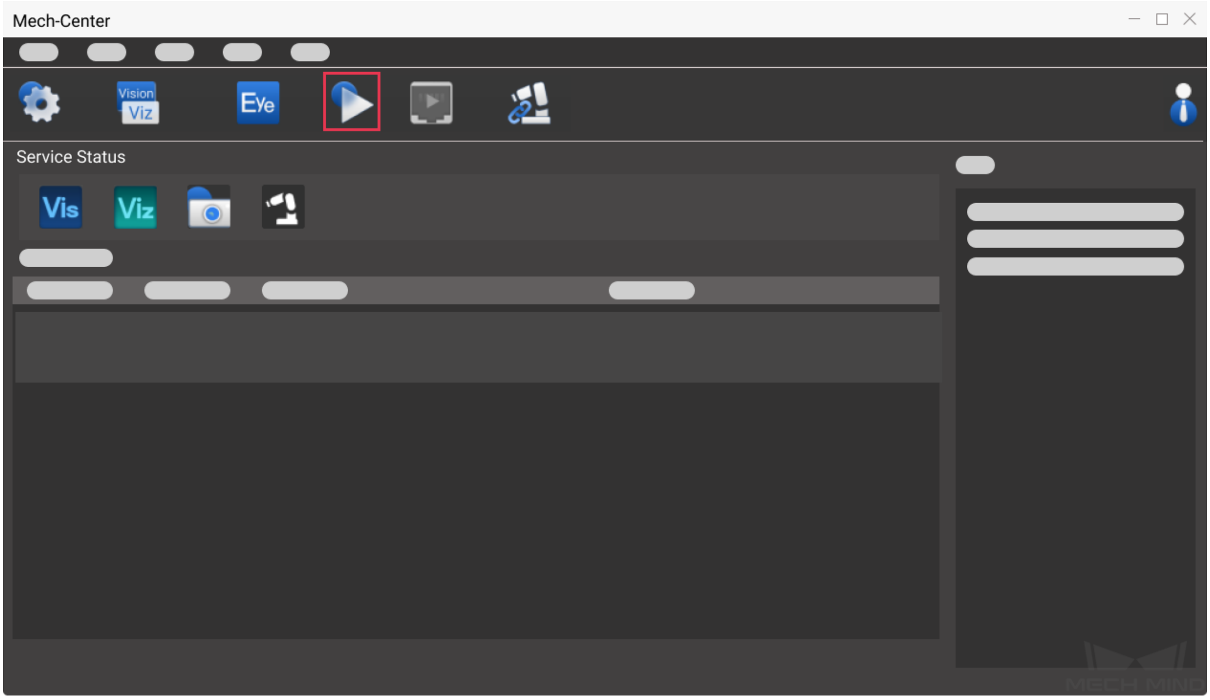
In the toolbar, adjust the **Robot Speed** to 5%.

> **Attention:** Be sure to turn down the robot movement speed!

2. Uncheck **Run as simulation**.

Mech-Center → Deploymrent Settings → Mech-Viz

3. Run



If the robot moves according to the planned trajectory and picks up and places the box, then you have successfully completed the first pick and place.

Attention: When running the robot, please ensure personnel safety. When an emergency occurs, please press the emergency stop button on the teach pendant!