WRIST CAMERA VISION SYSTEM FOR UNIVERSAL ROBOTS INSTRUCTION MANUAL

ROBOTIQ

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Revisions

Robotiq may modify this product without notice, when necessary, due to product improvements, modifications or changes in specifications. If such modification is made, the manual will also be revised, see revision information. See the latest version of this manual online at: http://support.robotiq.com/.

2017-06-07

Updated Section 3.6 for URCap package installation procedure

Updated Section 4.2 for calibration process

Updated Sections 5.2, 5.2.1, 5.2.2, 5.2.3 for new and improved teaching methods.

Added Section 6.2 to use advanced programming with the vision system.

Updated technical specifications (Section 7.3).

Updated calibration board for UR5 and UR10 robots (Section 4)

2016-11-16
Updated specifications (section 6)
Updated installations instructions (section 4)
Added Troubleshooting instructions (section 9.1)

2016-08-26
First release

1. General Presentation

The terms "Camera" and "Wrist Camera" used in the following manual all refer to the Robotiq Wrist Camera, while the term "Vision" and "Vision System" used in the following manual all refer to the Robotiq Wrist Camera Vision System for *Universal Robots*. This Vision System uses the Robotiq Wrist Camera and the Camera Locate software on *Universal Robots* to provide you with a simple object teaching interface. This interface allows to set up the Vision System so it can recognize objects location and orientation automatically. The Vision System, using the Camera Locate feature, is only designed to locate one part at the time on a predefined workplane. It gets the part's position (x, y) and orientation along the z axis. It allows to operate the robot according to the object location. The Camera is designed to work in industrial applications in combination with the Robotiq 2-Finger Adaptive Gripper.

Note
The following manual uses the metric system, unless specified, **all dimensions are in millimeters**.

Note
The following section presents the key features of the Vision System and must not be considered as appropriate to complete operation, each feature is detailed in the appropriate section of the manual. Safety guidelines must be read and understood before any operation is attempted with the system.

Vision System components :

Figure 1.1 describes the various components of the Robotiq Vision System for Universal Robots. This system will use the Robotiq Wrist Camera, mounted on any of the *Universal Robots* (UR3, UR5, UR10) using a CB3.1 controller or greater. For a list of provided components with your Robotiq Wrist Camera kit for *UR* please consult the Scope of Delivery section.

Note
Robotiq Vision System is only compatible with *Universal Robots* with controller CB3.1 and above, to identify your controller, please contact your *U niversal Robots* representative.

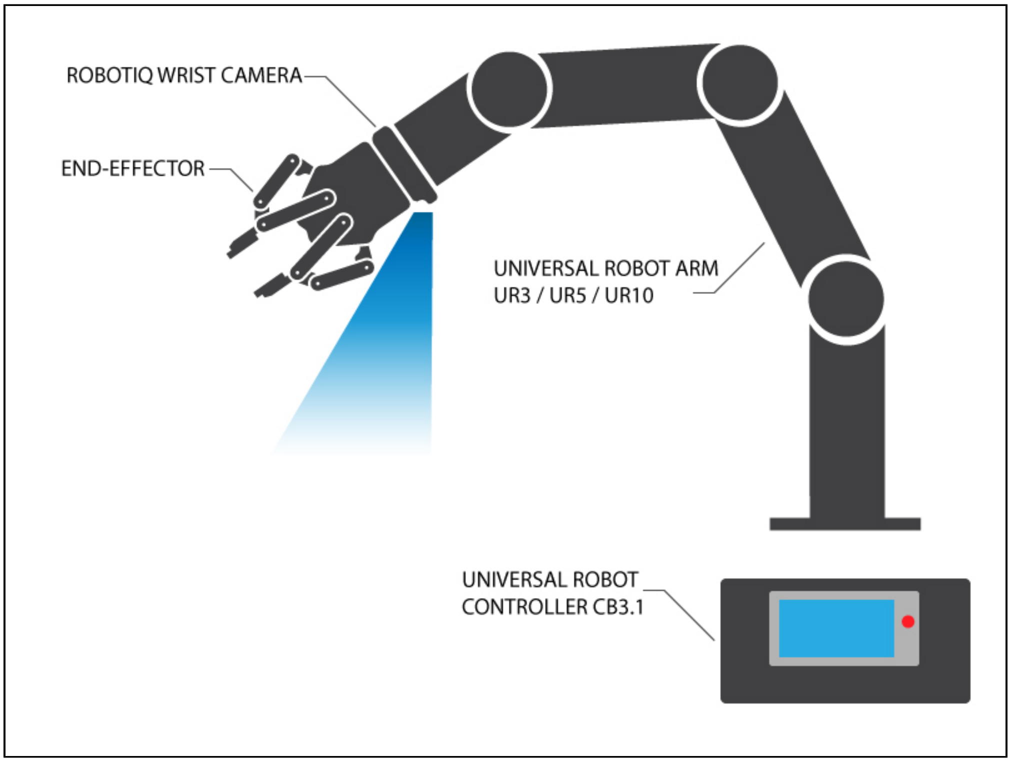


Figure 1.1: Schematic representation of the Robotiq Wrist Camera Vision System hardware.

- Robotiq Wrist Camera: Described in details in sub-section Wrist Camera below.
- End effector: Any tool mounted on the robot for it's application, the Wrist Camera is meant for direct integration of the Robotiq 2-Finger Adaptive Gripper.
- Universal Robot Arm: Any of the UR3, UR5 or UR10 model from *Universal Robots*.
- Universal Robot Controller: Controller model CB3.1 from *Universal Robots.*

Snapshot Position & Workspace :

Figure 1.2 illustrates the various terms used in the following manual to describe the Vision System Snapshot Position and workspace. The object location process will always start at the Snapshot Position, that position will determine the field of view of the Camera and thus the workspace. See section 4 for details on how to teach the Snapshot Position.

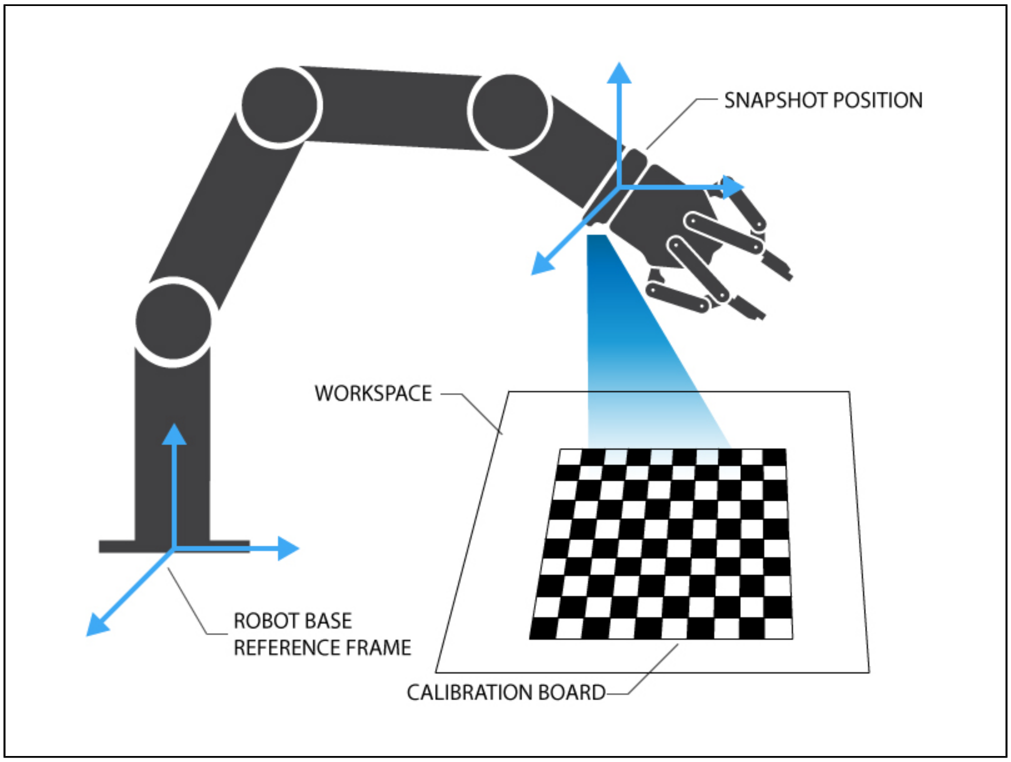


Figure 1.2: Schematic representation of the Robotiq Vision System Snapshot Position and workspace concepts.

- Snapshot Position: the robot pose use to take snapshots from the Wrist Camera.
- Workspace: the area of interest for the Vision System, it is defined by the Camera's field of view.
- object: the object you want to locate using the Vision System.
- Calibration board: a grid provided with your Camera UR Kit used during the calibration process of the Snapshot Position.

Object Location :

The System will use the Camera Locate node described in section 5 to locate the object. Figure 1.3 below represents the object location process. See section 5 for details on the object location process.

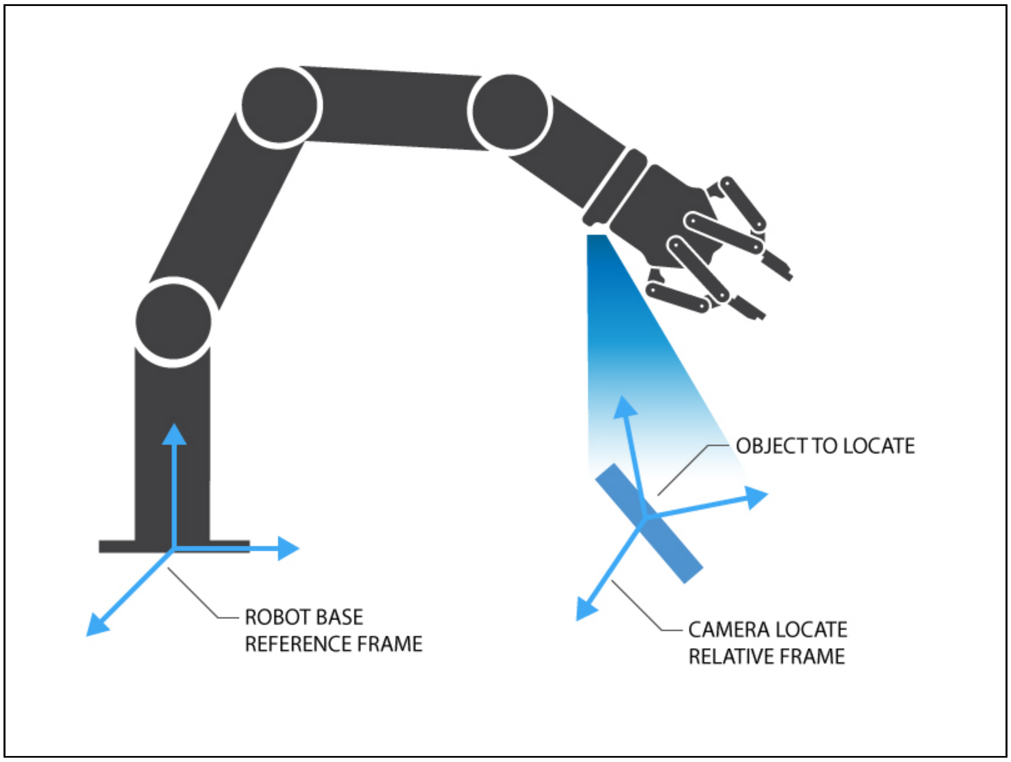


Figure 1.3: object location process schematic representation.

- Object to locate: The object you want to locate with coordinates X & Y and rotation Rz.
- Camera Locate relative frame: The reference frame updated by the Vision System to provide you with the object location.
- Robot base frame: The reference frame of the Universal Robot. Coordinate [0,0,0].

Wrist Camera :

The hardware at the center of the Vision System is the Robotiq Wrist Camera illustrated in figure 1.4. Steps on how to install the Wrist Camera are explained in section 3.

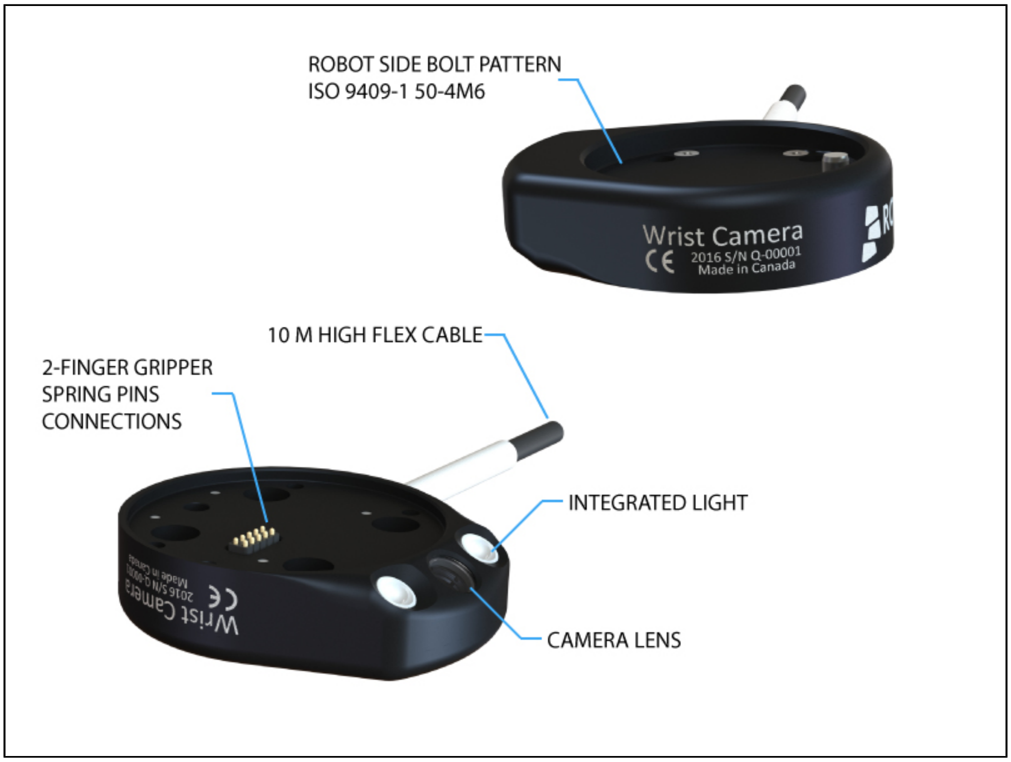


Figure 1.4: Wrist Camera main features.

The Robotiq Wrist Camera main features:

- CMOS image sensor with liquid lens:
    - Resolution: 0.3 to 5 Mpx;
    - Frame rate: 2 to 30 FPS;
    - Focus from 70 mm to infinity, automatic control.
- 2 sets of 3 LEDs:
    - Integrated lighting with automatic control.
- Single high-flex 10 meter pigtail cable:
    - USB 2.0;
    - 24V DC power.
- ISO 9409-1-50-4M6 bolt pattern, both sides:
    - Direct mounting on the UR;
    - Direct mounting of the 2-Finger Adaptive Gripper on the Camera.

> **Info**
> The Robotiq Wrist Camera provides a direct mounting interface for the Robotiq 2-Finger Adaptive Gripper, providing a mechanical interface, 24 V power and communication to the Gripper.

2. Safety

Warning
The operator must have read and understood all of the instructions in the following manual before handling the Robotiq Wrist Camera Vision System for *Universal Robots*.

The term "operator" refers to anyone responsible for any of the following operations on the Wrist Camera Vision System and associated robot or tools :

- Installation
- Control
- Maintenance
- Inspection
- Calibration
- Programming
- Decommissioning

This document explains the various components of the Vision System, as well as general operations regarding the whole lifecycle of the product; from installation to operation and decommissioning.

The drawings and photos in this document are representative examples and differences may exist between them and the delivered product.

2.1 Warning

Note
Any use of the Vision System in noncompliance of these warnings is inappropriate and may cause injury or damage.

Warning
Wrist Camera Vision System used in human-robot collaboration must not be considered a complete safety measure, additional dedicated safety device(s) must be considered. Vision System failure can occur and result in danger for workers or machinery if not properly secured. See local or international safety measure for human-robot collaboration.

Warning

- The Camera needs to be properly secured before operating the robot.
- Do not install or operate a Camera that is damaged or lacking parts.
- Never supply the Camera with an alternative current.
- Make sure all cord sets are always secured at both ends, at the Camera and at the robot.
- Always respect the recommended keying for electrical connections.
- Be sure no one is in the robot and/or Camera path before initializing the robot's routine.
- Always respect the Camera payload.
- All local safety measures and/or laws on robot operation must be applied to the Vision System.

  Any use of the Vision System in noncompliance with these warnings is inappropriate and may cause injury or damage.

2.2 Intended Use

The Vision System is designed to locate objects laying flat on the defined workspace. The system can identify and locate multiple kind of objects, each object will require it's own part teaching process as explained in section 5. The Vision System gets the part's position (x, y) and orientation along the z axis. It allows to operate the robot according to the object location.

Tip
Section 4.1 will give you advice on what workspace should be usde or avoided. Section 5.1 will give you advice on what objects can be located or not along with background recommendations.

Caution
The Vision System is NOT intended for:

- Metrology
- Bar-code / QR code reading

The product is intended for installation on a *Universal Robots* model UR3, UR5 or UR10 using CB3.1 controller only.

Note
Always comply with local and/or national laws, regulations and directives on automation safety and general machine safety.

The unit may be used only within the range of its technical data. Any other use of the product is deemed improper and unintended use. Robotiq will not be liable for any damages resulting from any improper or unintended use.

3. Installation

The following subsections will guide you through the installation and general setup of your Robotiq Wrist Camera Vision System.

- Section 3.1 details the scope of delivery for the Wrist Camera kit for UR, verify your package.
- Section 3.2 lists the required tools, parts and equipment for proper use of your Camera.
- Section 3.3 explains the operating conditions that must be met for the 2-Finger Gripper to operate normally.
- Section 3.4 guides you through the mechanical installation using the Wrist Camera and other optional parts.
- Section 3.5 describes the required electrical set up of the Gripper, its power source and cable management.
- Section 3.6 guides you through the software installation.

Warning
Before installing :

- Read and understand the safety instructions related to the Vision System.
- Verify your package according to the scope of delivery and your order.
- Have the required parts, equipment and tools listed in the requirements ready.

Warning
When installing :

- Satisfy the environmental conditions.
- Do not operate the Vision System, or even turn on the power supply, before the Camera is **firmly anchored** and the **danger zone is cleared**.

3.1 Scope of Delivery

Wrist Camera Kit for Universal Robots:

RWC-UR-KIT

Standard upon delivery:

- Robotiq Wrist Camera with 10m High-Flex pigtail cable **RWC-CAM-001**;
- Universal Robots pattern tool plate **RWC-TOOL-062**;
- 16 Gig USB stick **ACC-USB-16G**;
- USB software licence dongle **ACC-USB-DONGLE**;
- 4 ports USB hub **ACC-USB-4-HUB**;
- Calibration board **ACC-CALIB-BOARD**;
- Colored background for object teaching **ACC-TEACH-BACK**;
- Hardware kit for fixing Wrist Camera on Universal Robots.

> **Note**
> The hardware for fixing a tool on the Wrist Camera is not provided.

Combo of 2-Finger Adaptive Gripper and Wrist Camera for Universal Robots:

CUR-AGC-085-RWC or CUR-AGC-140-RWC

Standard upon delivery:

- Wrist Camera Kit for Universal Robots includes:
  - Robotiq Wrist Camera with 10m High-Flex pigtail cable **RWC-CAM-001**;
  - 16 Gig USB stick **ACC-USB-16G**;
  - USB software licence dongle **ACC-USB-DONGLE**;
  - 4 ports USB hub **ACC-USB-4-HUB**;
  - Calibration board **ACC-CALIB-BOARD;**
  - Colored background for object teaching **ACC-TEACH-BACK**;
  - Hardware kit for fixing Wrist Camera on Universal Robots.
- Gripper parts :
  - Basic Gripper unit (85 or 140) **AGC-GRP-002 or -140** (depending on your combo);
  - Screw kit for fixing Gripper on Wrist Camera.

3.2 Required Tools and Equipment

The following tools are required to install the Wrist Camera:

- 2 mm slotted screw driver to do terminal block connections when wiring.

Provided tools with the Wrist Camera:

- 4 mm hex key to mount the Camera on the UR.

Optional tools if installing 2-Finger combo: **CUR-AGC-085-RWC** or **CUR-AGC-140-RWC** :

- none, use the provided 4 mm hex key.

The following parts are required for setup:

- Universal Robots UR3, UR5 or UR10 along with it's controller;

> **Warning**
> The system is only compatible with UR CB3.1 controller, check your controller version.

- Universal Robots' PolyScope version must be 3.3 and higher in order to install the URCap.
- Power supply if not using Universal Robots controller supply (see below);
- Fuse, see information below.

The Camera needs to be supplied by a DC voltage source. This power supply is not included with the Camera kit for UR. Required power supply must match the Robotiq device. The following table shows the specifications with regards to the power supply required to operate the Camera and the optional Robotiq Gripper.

SPECIFICATION	VALUE
Output voltage	24 V DC ±10%
Output current	1 A
Overcurrent	Recommended power supply with internal protection, otherwise fusing is required. 2 A fuse at 25°C [77°F][1]

Table 3.2.1 : Robotiq Wrist Camera and 2-Finger power supply requirements.

> **Info**
> [1] Suggested fuse is a: Phoenix Contact # 0916605 2 A thermal, use AWG #20 wiring.

> **Warning**
> If your power supply could exceed the specified regulation, over-voltage protection is required.

Robotiq recommends the use of the following power supplies:

- For the 1A output current: TDK-Lambda DPP Series, *100W Single Output DIN Rail Mount Power Supply*: **DPP30-24.**

3.3 Environmental and Operating Conditions

The Wrist Camera is designed for industrial applications. Always respect the following specified operating environmental conditions:

Condition	Value
Minimum storage/transit temperature	-30°C [-22°F]
Maximum storage/transit temperature	70°C [158°F]
Minimum operating temperature	0°C [32°F]
Maximum operating temperature	50°C [122°F]
Humidity	Non-condensing.
Others	Lense must be free from dust, soot and water. Environment must be free from powerful electromagnetic interference. Environment must be free from corrosive or explosive liquids or gases.

Table 3.3.1: Environmental and operating conditions for the Wrist Camera.

3.4 Mechanical Installation

Wrist Camera kit for Universal Robots

For mechanical installation of a Wrist Camera on a UR robot along with an end-effector (other than Robotiq's 2-Finger Gripper), follow these instructions and refer to Figure 3.4.1:

- Place the Wrist Camera (RWC-CAM-001) on the robot arm. Align the camera's indexing (dowel) pin properly in Universal Robots' bolt pattern.
- Place the tool plate (RWC-TOOL-062) on the camera. Align the tool plate's indexing (dowel) pin correctly in the Wrist Camera.
- Fix the desired end-effector on the robot arm, through the tool plate and the camera, using M6 screws.
- Fix the cable along the robot arm, see Cable Management section.

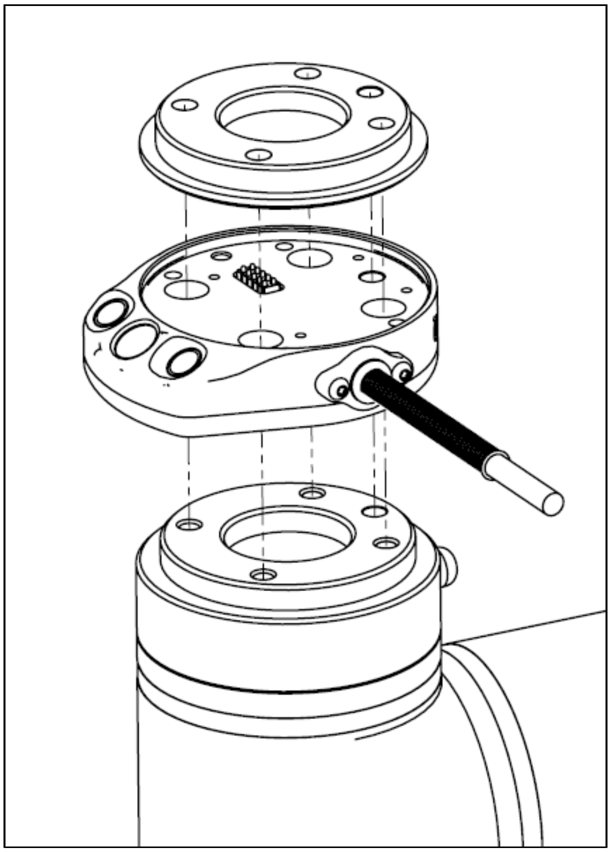


Figure 3.4.1: Mechanical installation of the Wrist Camera kit for Universal Robots.

The end-effector is not screwed in the camera or the tool plate, but directly in the robot arm. Both camera and tool plate have through holes for this assembly.

Hardware
M6 screws to mount an end-effector on the Wrist Camera are not provided. Use M6 screws of appropriate length to secure the end-effector on the robot arm.

Combo of 2-Finger Adaptive Gripper and Wrist Camera for Universal Robots

For mechanical installation of a Wrist Camera on a UR robot along with Robotiq's 2-Finger Gripper, follow these instructions, and refer to Figure 3.4.2:

- Place the Wrist Camera (RWC-CAM-001) on the robot arm. Align the camera's indexing (dowel) pin properly in Universal Robots' bolt pattern.
- Fix the camera on the robot arm using the provided M6 X 12 LHCS screws and lock washers.

> When mounting only the Wrist Camera on the robot, the spring pins that would ensure connection to a Robotiq 2-Finger Gripper are exposed. Be careful not to harm them.

- Mount the gripper directly on the Wrist Camera using the provided M5 X 35 SHCS and lock washers.
- Fix the cable along the robot arm, see Cable Management section.

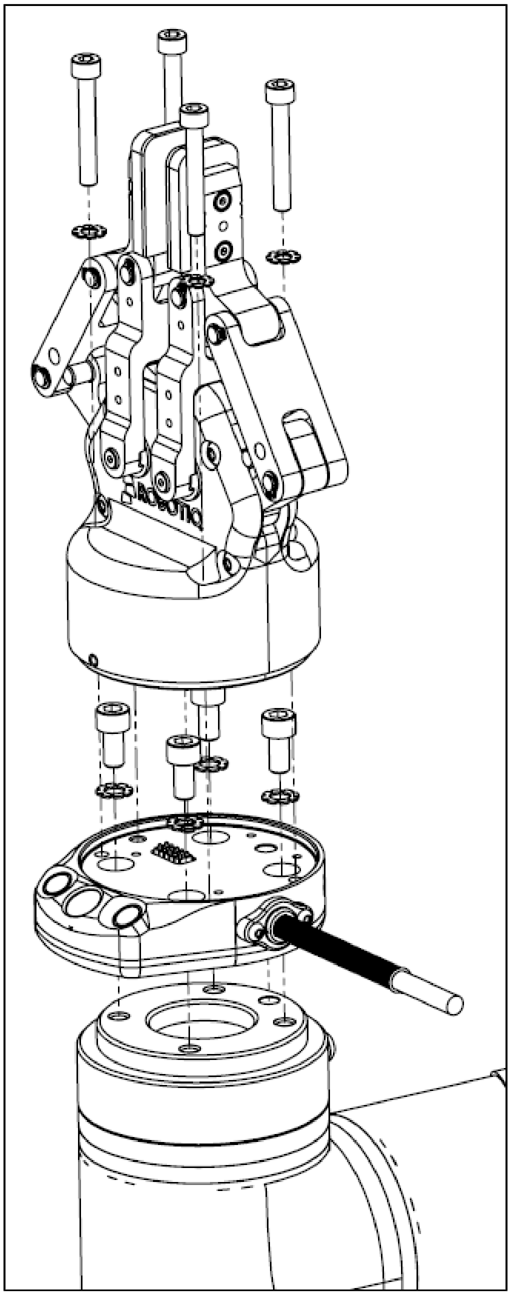


Figure 3.4.2: Mechanical installation of the Combo of 2-Finger Gripper and Wrist Camera for Universal Robots.

3.5 Electrical Setup

Power Supply :

> **2-Finger Gripper**
> If mounting a 2-Finger Gripper on the Wrist Camera, the Camera replaces the gripper's coupling. Therefore, only the Wrist Camera's device cable is required to provide power and communication to both the camera and the gripper. The wiring for setups including only the camera or both the camera and the gripper is the same.

Power and communication are established with the Wrist Camera via the high-flex device cable. The cable provides a 24 V power supply to the Wrist Camera and enables USB 2.0 communication with the Universal Robots controller.

Follow these steps to correctly wire the Wrist Camera (or the camera and 2-Finger Gripper combo) to a Universal Robots controller :

- With the controller turned off, connect the red (24 V) and black (0 V) wires of the device cable as shown in Figure 3.5.1. Use any available 24 V and 0 V.

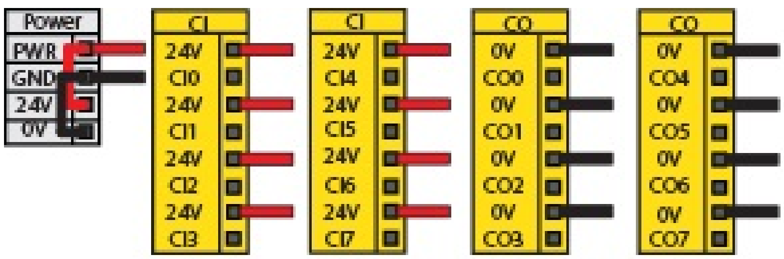


Figure 3.5.1: Power supply wiring on CB3.1 Universal Robots controller.

- Connect the 4 ports USB hub (ACC-USB-4-HUB) inside the robot controller.
- Connect the Wrist Camera's USB connector in the 4 ports USB hub.
- Connect the licence USB dongle (ACC-USB-DONGLE) in the 4 ports USB hub.

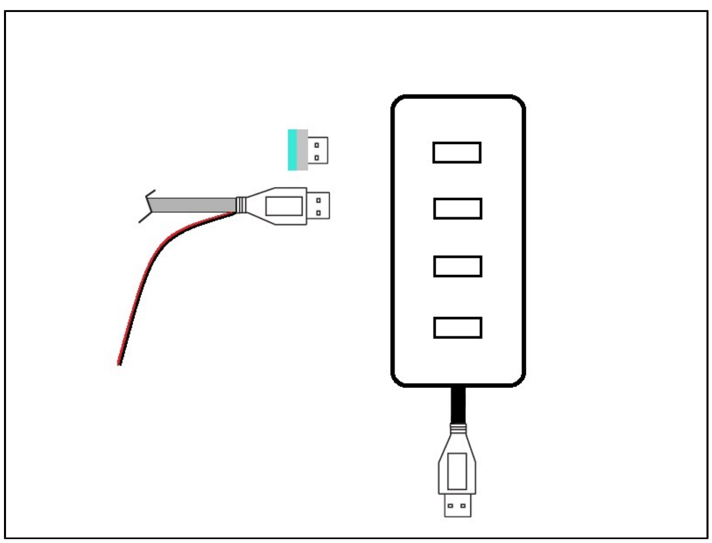


Figure 3.5.2: 4 ports USB hub connection.

Wrist Camera grounding is optional and is done via the robot ground. The camera's indexing pin (dowel) is the ground connector.

Cable Management

> **Cable management**
> Use proper cabling management. Be sure to leave enough excess cable to allow full robot movement without pulling out the connectors. Always protect the controller-side (robot side) connector of the cable with a strain relief cable clamp.

3.6 Software

Make sure the Wrist Camera is properly mounted on the robot arm and that all electrical wiring is correctly done (refer to Section 3.4 and 3.5). Make sure your Universal Robots' software is up to date. Polyscope must be at least a 3.3 version in order to install a URCap.

- Refer to Section 3.6.1 for the installation procedure.
- Refer to Section 3.6.2 to update the version or uninstall.

Do not unplug the 16 Gig USB stick or the USB licence dongle, even after the installation has been completed.

Center of Mass
Prior to use over *Universal Robots*, adjust the center of mass and payload from the Installation tab (refer to Section 7.1.1).

3.6.1 Wrist Camera URCap Installation

Make sure the Wrist Camera is properly mounted to the robot arm and that all electrical wiring is correctly done (refer to Section 3.4 and 3.5). Make sure your Universal Robots' software is up to date. Polyscope must be at least a 3.3 version in order to install a URCap (version 3.3.3.292 on the release date of this manual).

> **Update**
> For the URCap update, refer to Section 3.6.2 to uninstall prior to installation.

Wrist Camera Locate URCap Installation

- From support.robotiq.com, visit the vision system page and download the latest **UCC-X.X.X** compressed file.
- Uncompress the content of the latest **UCC-X.X.X** compressed file on the provided 16 Gig USB stick (ACC-USB-16G).
- Make sure the urcap file and the vision system folder are on the root of the USB drive as shown in Figure 3.6.1.1.

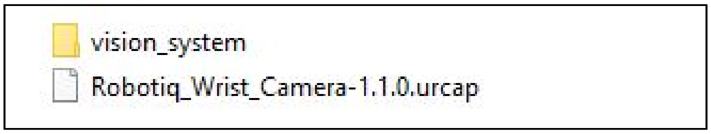


Figure 3.6.1.1: Files on the root of the 16 Gig USB stick.

- With the robot controller on, insert the 16 Gig USB stick in the 4 ports USB hub.

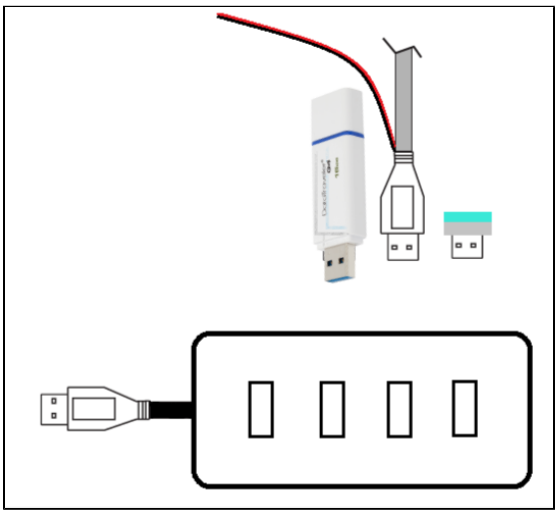


Figure 3.6.1.2: Connections on the 4 ports USB hub.

- From Polyscope's home page, tap **Setup Robot** and go in **URCaps Setup**.
- Tap the plus (**+**) sign and open **Robotiq_Wrist_Camera-X.X.X.urcap** from the USB stick.
- Tap **Restart** and wait for Polyscope to reopen.
- Go in **Program Robot** and then in the **Installation** tab.
- Choose **Camera** and go in the **Dashboard** tab.
- Verify the Vision system's status.

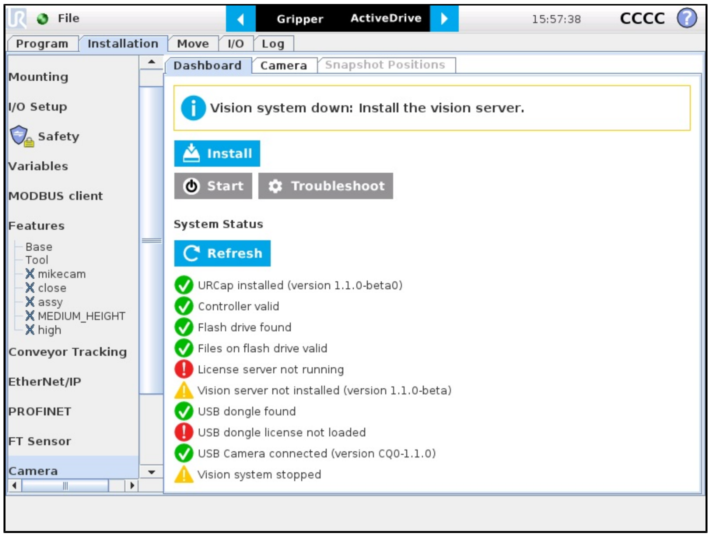


Figure 3.6.1.3: Camera dashboard ready to install the vision server.

- Tap **Install** and wait for the vision server to be installed.
- If the firmware has to be updated, tap **Upgrade Camera firmware** to upgrade it before continuing (refer to Figure 3.6.1.4).

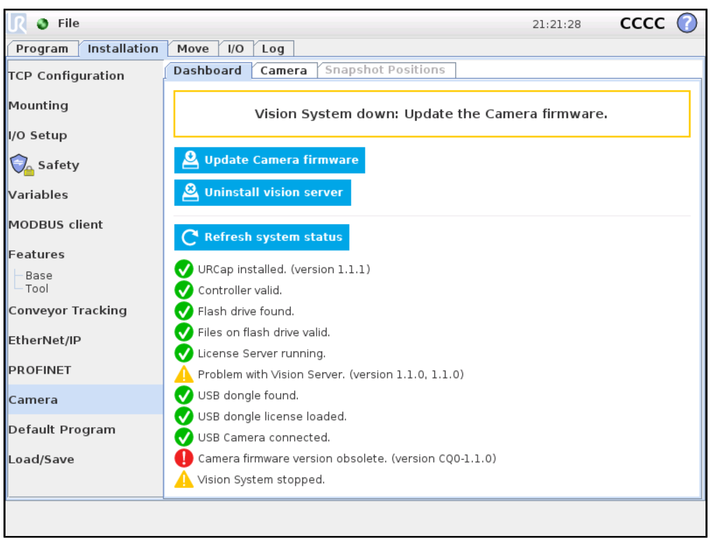


Figure 3.6.1.4: Camera dashboard with camera firmware upgrade

- Wait for the vision system to start.
- The installation is completed.
- In order to use another USB drive on the controller, reboot the robot controller.

Do not unplug the 16 Gig USB stick or the USB licence dongle, even after the installation has been completed.

Dashboard
The Dashboard tab contains helpful information for troubleshooting the vision system.

Test the Installation

After the installation has been completed, verify that the vision system works properly.

1. From a robot program, go in the **Installation** tab and choose **Camera**.
2. Go in the **Dashboard** tab and verify the system's status. Make sure the vision system is running.
3. Go in the **Camera** tab. The output image will appear.

Center of Mass
Prior to use over *Universal Robots*, adjust the center of mass and payload from the **Installation** tab (refer to Section 7.1.1).

3.6.2 Update and Uninstall

Version 1.1 and following

1. From a robot program, go in the **Installation** tab.
2. Click on **Camera** and go in **Dashboard**.
3. Tap **Stop camera**.
4. Tap **Uninstall**.
5. Remove the 16 Gig USB stick.
6. Go in **Setup** Robot.
7. Tap **URCaps Setup**.
8. In the Active URCaps text box, tap the Camera URCaps.
9. The Camera URCaps should be highlighted.
10. Tap the minus button (**-**) to uninstall the URCaps.
11. **Restart** Polyscope to complete the uninstall process.
12. Turn off or reboot the controller.
13. Disconnect the 16 Gig USB stick from the controller and connect it to a PC.
14. Format it using FAT32.
15. Follow the procedure from Section 3.6.1 to install the newest software.

Version 1.0.2 and Previous

1. On a blank USB stick, add the following file : urmagic_uninstall.sh .
2. From a **Robot Program**, go in the **Installation** tab. Choose **Camera** and go in the **Camera** tab.
3. Tap **Stop camera** to stop the Vision server.
4. With the controller on, insert the USB stick containing the urmagic file in the UR teach pendant. Automatic uninstall will begin.
5. Wait for the uninstall to be completed. Remove the USB stick containing the urmagic file.
6. Remove the 16 Gig USB stick containing the vision server.
7. From the home page, go in **Setup** Robot.
8. Tap **URCaps Setup**.
9. In the Active URCaps text box, tap the Camera URCaps.
10. The Camera URCaps should be highlighted.
11. Tap the minus button (**-**) to uninstall the URCaps.
12. Turn off or reboot the controller
13. Disconnect the 16 Gig USB stick from the controller and connect it to a PC.
14. Format it using FAT32.
15. Follow the procedure from Section 3.6.1 to install the newest software.

4. Snapshot Position

Prior to teaching object with the Camera Locate URCaps node (see section 5), the operator must define a Snapshot Position using the Snapshot Position wizard. The following section and sub-sections will guide you through this process.

Requirements:

- You must have completed the installation steps of section 3.
- Robot must set up to reach the desired workspace.
- You must have the correct calibration board in hand.

Reminders:

- You can teach as many Snapshot Positions as you want.
- Snapshot Position is where the robot is positioned to search for objects.
- One Snapshot Position can be used to search many objects.
- When the object teaching process of section 5 is done, it is linked to the Snapshot Position and you cannot change that position.
- Each Snapshot Position along with the workplane will define a workspace according to the field of view of the Camera. See section 7 for details on the field of view.

Calibration Boards:

> **Tip**
> If you are viewing a printed version of this manual, please visit support.robotiq.com to download the file.

- For UR5 and UR10

Along with your kit you will have the calibration board used for UR5 and UR10 on one side of the board, part number **ACC-CALIB-BOARD**.
If you loose or damage your board, you can print the following file:

> **Note**
> If you are viewing the PDF version of the manual, please visit the online version of this manual at support.robotiq.com to get the calibration board files. If you have printed this manual, please stop doing so, save some trees and visit the website.

> **Info**
> UR5 and UR10 calibration board must be printed on Letter (11" x 17") or A3 paper, make sure scale is at 100%. You can validate that your calibration board had the good scale by measuring the scale on your sheet.

- For UR3

Along with your kit you will have the calibration board used for UR3 robots on one side the the board, part number **ACC-CALIB-BOARD**. The color balance circles are not used yet with the vision system and are for future use. If you loose or damage your board, you can print the following file:

> **Info**
> UR3 calibration board must be printed on Letter (8.5" x 11") or A4 paper, make sure scale is at 100%. You can validate that your calibration board had the good scale by measuring the scale on your sheet.

4.1 Guidelines on Snapshot Position

Ambient lighting
During the snapshot position definition, the ambient light must be of approximately 500 lux. At run-time, this condition is not required.

The following must be considered when choosing your Snapshot Position:

- Choosing the workspace:
  - Mostly uniform color;
  - Planar;
  - Provide contrast to your part, see Section 7.3 for details.
- Distance to the workplane:
  - Your Snapshot Position will determine the field of view of the camera and thus the workspace used afterwards.
    - See specifications in Section 7.3 for details on the field of view & part size;
    - Getting closer to the workplane, will reduce your workspace but allow you to locate smaller objects;
    - Getting away from the workplace will increase the workspace but will increase the minimum size of objects to locate.

      Tip
      During the Snapshot Position define step, use the "Show Grid" button, a grid will appear. You object should be bigger then one grid cell.

- Angle of the camera:
  - Snapshot position should consider the Camera angle:
    - Robotiq greatly recommends to have the Camera perpendicular to the surface:
      - Be as close as possible to perpendicular, avoid reflections.
    - Object should be seen from the top view, not from the side.
- Calibration board:
  - Snapshot position does not need to see the full calibration board, calibration step does.

    Tip
    The Snapshot position and Calibration pose are decoupled, they do not need to be the same.

  - Use the appropriate calibration board.
  - Board must be fully visible by the Camera.
  - Refer to Section 7.3 for Calibration board position specifications.

4.2 Snapshot Position Wizard

Feature Point:

Prior to defining the Snapshot Position, the operator must define a feature point. To do so, from the *Universal Robots Polyscope* interface:

- Start a new program or open yours, then go to the **Installation** tab.
- Go to **Features**.
- Tap **Point** to insert a new point feature.
- Select that point, check the **Variable** checkbox.
- Define that point position anywhere by tapping **Set this waypoint**, then tap **OK**, actual position does not mater.
- Tap **Rename** to give a significant name to your feature, that name will be used as a reference frame later on in your program.

> **Info**
> Each Snapshot Position you teach will require its own Feature point.

Snapshot Position Wizard:

Snapshot Position is define using the Snapshot Position Wizard, from the Universal Robots Polyscope interface, still within the **Installation** tab:

- Go to **Camera**.
- Go to the **Snapshot Positions** tab.
- In the drop-down list, select the **Feature** you wish to use.
- Tap **Define** to launch the wizard.

Wizard step 1: **Define Snapshot Position**

- Move the robot arm using the **Freedrive** to place the Wrist Camera.
  - Remember the guidelines from section 4.1:
    - Distance will determine field of view and size of objects to be located.
    - Use the Show Grid to help you choose distance (object at least one cell).
    - Camera view should be quasi perpendicular to surface.
- Once the robot arm is in a proper position, tap **Save position**. Wizard will go to next step.

Wizard step 2: **Calibrate**

- Place the appropriate calibration board in the field of view of the camera
  - Remember to use the appropriate board, according to your robot model
  - The board orientation should match the screen - landscape orientation
  - Make sure the Camera see the whole board

    > **Tip**
    > Snapshot Position will determine the field of view, notice that the calibration step position does not have to be the same as Snapshot position. Thus, you can have a small field of view, then move back for calibration step.

  - Tap **Calibrate** to begin calibration

    > **Warning**
    > Calibration is an automatic process, the robot will move in order to perform calibration. Make sure the robot workspace is clear. You can tap Cancel to stop the process. Operator should watch the robot at all time and have emergency stop button at hand.

  - The Vision System will center on the board and take 27 poses of the board.
  - After the 27 poses, it will take 9 more photos for validating.
  - When the process is done, you will be asked to **Accept** or **Re-Calibrate**.
    - **Accept** if the calibration board grid is match on all pose (first 27 poses)
    - **Re-Calibrate** if the grid is not matched
  - The wizard will show the 9 validating poses.
  - Verify that the accuracy on the validation poses according to the color chart.
    - Dark blue: local accuracy of +/-0mm.
    - Dark red: local accuracy of +/-4mm and over.

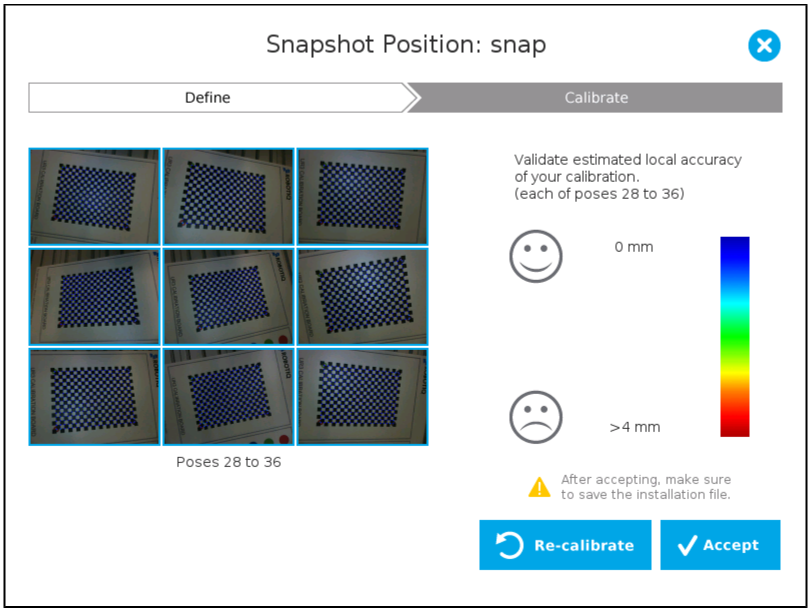


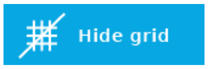
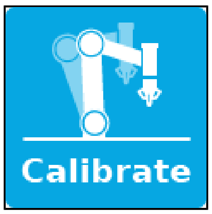
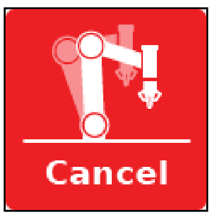
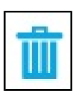
Figure 4.2.1: Validating poses.

- If the accuracy is larger than +/- 4mm, an message will inform you that you should perform the calibration again.
- When you tap **Accept**, you will exit the wizard and the process is completed.

Once the calibration has been accepted, the Snapshot Position will appear in the Snapshot Positions tab with the name of the Feature Point previously created. You can define other Snapshot positions, as long as you define new Feature Points. To delete a Snapshot Position, tap the bin.

> **Tip**
> Make sure you save the Installation file (tap Load/Save from Installation tab) in order to save the Snapshot positions created.

Features

Icon	Feature	Description
	Define	Launches the Snapshot Position definition wizard.
	Show grid	Displays a grid on the camera's field of view. Meant to test the camera’s height relative to the workplane : a part should be at least as large as a square of the grid.
	Hide grid	Hides the grid of the camera's field of view.
	Save position	Saves the robot position for the Snapshot Position. This is the position from which the robot will do the part detection.
	Calibrate	Starts the calibration procedure. The robot will move automatically to defined positions for the calibration.
	Cancel	Cancels the calibration procedure while it is running.
	Re-calibrate	Restarts the calibration procedure.
	Accept	Accepts the calibration process.
	Delete	Deletes a defined Snapshot position.

4.3 Copy a Calibration

When defining a snapshot position, it is possible to copy the calibration from another snapshot position. This allows for a faster snapshot position modification when using the same work plane.

> **Work Plane**
> To ensure proper precision, the work plane surface of both (new and copied) snapshot positions should be the same.

To copy a calibration, you need to have a snapshot position already defined from which you want to copy the calibration. From the **Snapshot Positions** tab, choose your feature point (view Section 4.2) and tap **Copy** instead of **Define**. Choose the snapshot position from which you want to copy the calibration. The wizard will launch automatically. Position the robot to the desired snapshot position and tap **Save position**. The calibration from the previously selected snapshot position will be used for this new one.

5. Object Teaching

Once the snapshot position is defined (see section 4), the operator can use the Camera Locate node within a Universal Robot program to teach an object to locate. The following section and sub-sections will guide you through this process.

Requirements

- You must have completed the installation steps of section 3.
- Snapshot position is defined as per steps of section 4.
- Have the object to teach in hand:
  - Have a few samples to test during the last step of the object teaching process.

Reminder

- A Camera Locate node will be used for a single object.
- Object teaching is linked to the snapshot position, if you want to change snapshot position, you will have to do the object teaching process again.
- You can teach many objects, each one will use a Camera Locate node.

Background

- Have a background that provides a maximum of contrast with your part, see section 4.1 for guidelines.

> **Tip**
> A colored background is provided with the camera kit. Use either the yellow or pink side to ensure a good color contrast with the part.

5.1 Guidelines on Object Teaching

Ambient lighting
During the object teaching, the ambient light must be of approximately 500 lux. At run-time, this condition is not required.

The following must be considered when going through the object teaching process :

- Objects criteria for reliable localization:
  - Object is quasi-flat, respecting a maximum ratio of 1:1 between it's height and it's smallest dimension (view Section 7.3).
  - Top surface is mostly flat.
  - Object has a distinct shape, distinct features.

    Info
    Distinct shape would mean a part contour that has a sharp contrast with the background and ideally not symmetric. Distinct features are shapes present within the contour of your part that the vision system will be able to identify, such as holes, drawings, colors contrast, etc.

  - Not highly reflective
  - Not transparent

Object Teaching
For reflective objects, you can spray matt paint on it for the object teaching. For reflective objects or objects with too many features, you can print a drawing of the object, with the correct size, with only the features you wish to teach. You can also select only the area of the part you want to teach.

- Choosing the appropriate background:
  - Work plane around the part must be clear of any parts, planar and mostly uniform.
    - At run-time, the work space conditions can change, object detection threshold, explained in section 5.2.3, can be used to adjust detection settings according to those conditions.
  - That background around the part must be a uniform, continuous shape with a single color.

    Note
    From the vision system's point of view, white, gray and black are the same color - they are different gradients of gray. Do not use a black background to teach metal parts. This would be seen as a pale gray object on a dark gray background and would result in errors. Refer to Section 7.3 for specifications on color contrast.

  - When placing the background and the object in the camera's field of view for the **Photos** step, make sure you leave a uniform margin around the object as shown in Figure 5.1.1.

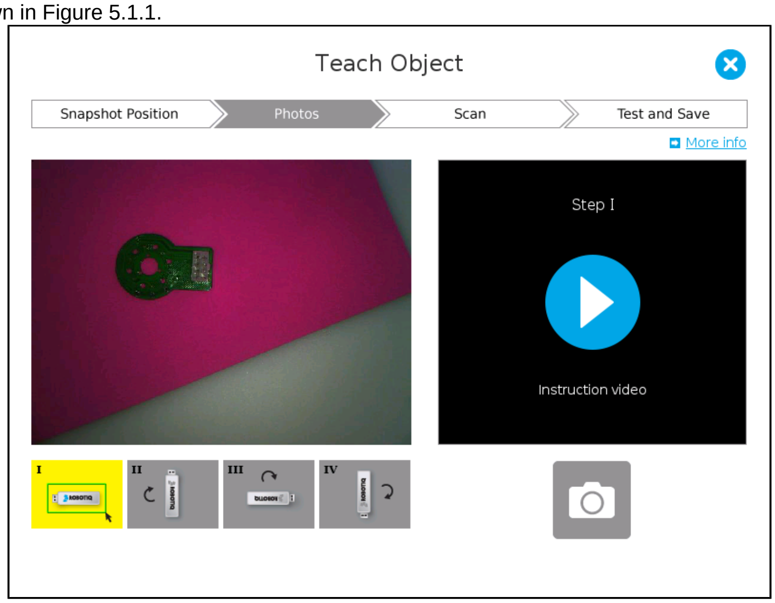


Figure 5.1.1: Placing the background and object for teaching.

  - The first photo requires the user to outline the area in which the part is. Make sure it is outlined as close to the part as possible.

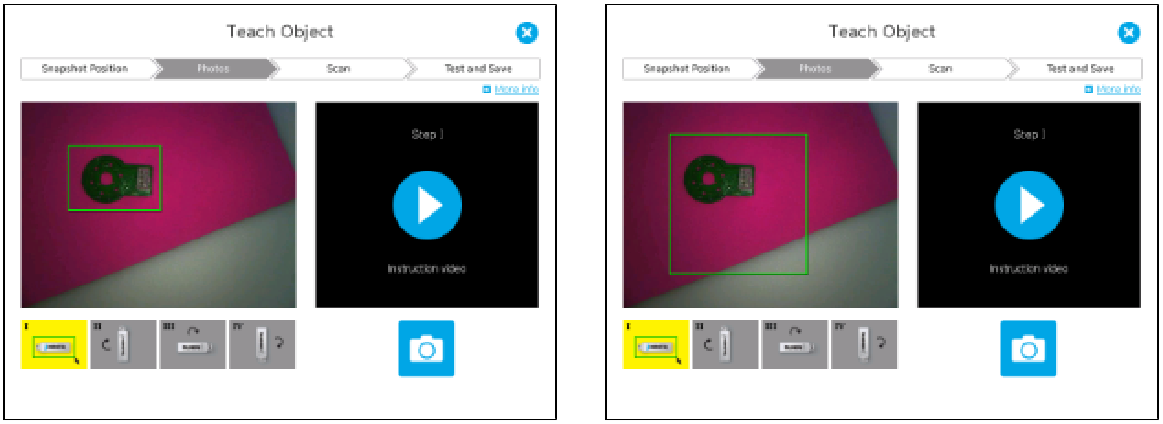


Figure 5.1.2: Example of a good (left figure) and bad outline (right figure) for the object teaching.

Work Plane
At run time, make sure you have the simplest and most uniform background possible for your application. Also have the least parts and part types possible. This will decrease the cycle time.

Ambient conditions

During the teaching process, it is important to have stable lighting

- At run-time, lighting can fluctuate, can also be compensated with object detection threshold

- The Wrist Camera has integrated lighting, your application should not need external lighting if you are in a normal working environment.

Lighting Recommendation
The ambient light should be diffuse. Avoid high light intensity spots on your background. This will result in a faster part detection by the Wrist Camera as well as less risk of false detection.

5.2 Teach Object Wizard

Camera Locate Node

To insert a Camera Locate node in the robot program, from the *Universal Robots Polyscope* interface:

- Start a new program or open yours, then go to the **Program** tab.
- Select the **Structure** tab.
- Go to the **URCaps** tab and tap **Cam Locate** to insert the node inside your program.

Teach Object Wizard

> **Reminder**
> Snapshot position must be defined to launch the object teaching wizard. If not, go to section 4.

The Teach object wizard will guide you through the process of teaching an object for camera localization. Select the **Cam Locate** node, go in the **Com mand** and tap **Teach object** to launch the wizard.

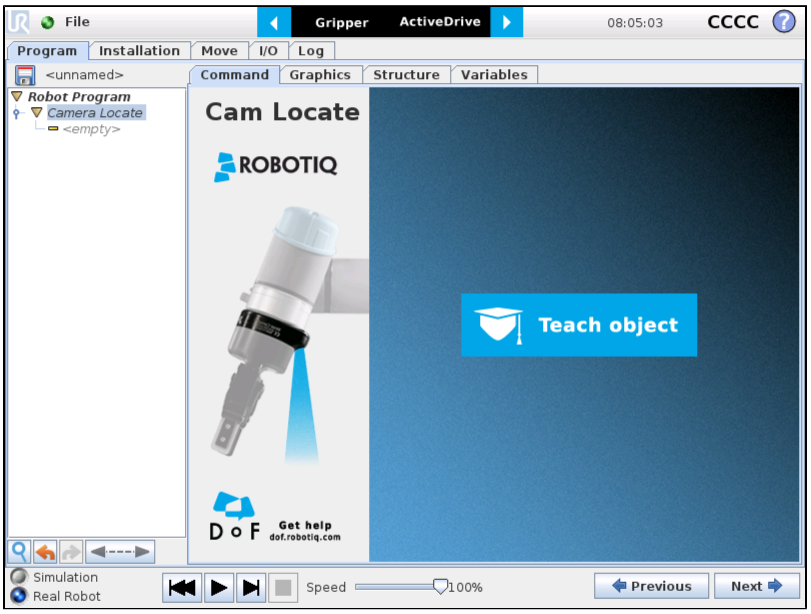


Figure 5.2.1: Launch the object teaching wizard.

Choose teaching method

The first step is to choose the teaching method. Choose between either the automatic or parametric method:

- **Automatic method**: builds a model based on photos and a scan of the object. Best for complex and irregular shapes. Use this method if the part orientation has to be detected with one of its features. Refer to Section 5.2.1.
- **Parametric method**: builds a model based on parameters of a basic 2D shape (circle, ring, square or rectangle). This method is faster and allows the vision system to recognize and locate with high robustness parts that have few distinctive features such as raw material blanks. Usually gives best results than the Automatic method for simple geometry and highly reflective parts. Refer to Section 5.2.2.

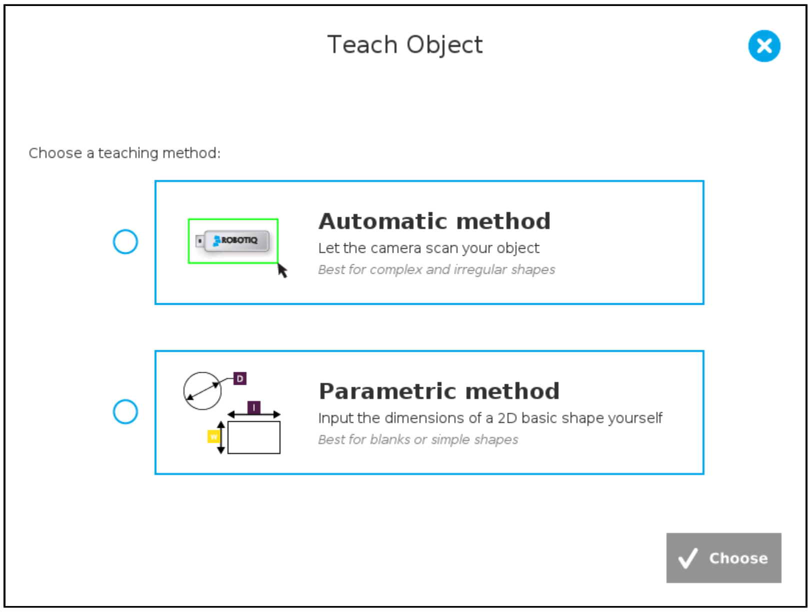


Figure 5.2.2: Choose the teaching method.

5.2.1 Automatic Method

> **Reminder**
> Snapshot position must be defined to launch the object teaching wizard, if not go to section 4.

Snapshot Position

Choose the **Snapshot Position** you want to use, then tap **Choose.**

- If the robot is not at that position, you will be asked to move to position. Tap and hold the **Move** button to do so.

Photos

- The first photo is the part on your teaching background. Place the background on the work plane and then place your object on it. On the teach pendant, select the area on which the object is located (tap, hold and slide your finger across the area to select it) as shown in Figure 5.2.1.1.

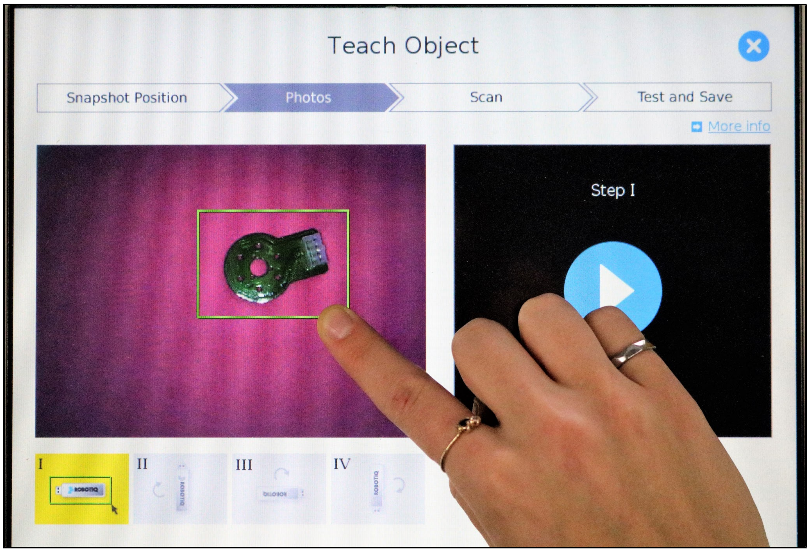


Figure 5.2.1.1: Tap and hold to outline the area on which the part is.

- You can use a different shape to outline the area on which the part is located, refer to Figure 5.2.1.2. Choose between a rectangle (default), circle or polygon area. Use the one that follows the best the part contour. For the circle area, tap to the center and hold to expand the circle. For the polygon area, tap on all corners of the polygon.

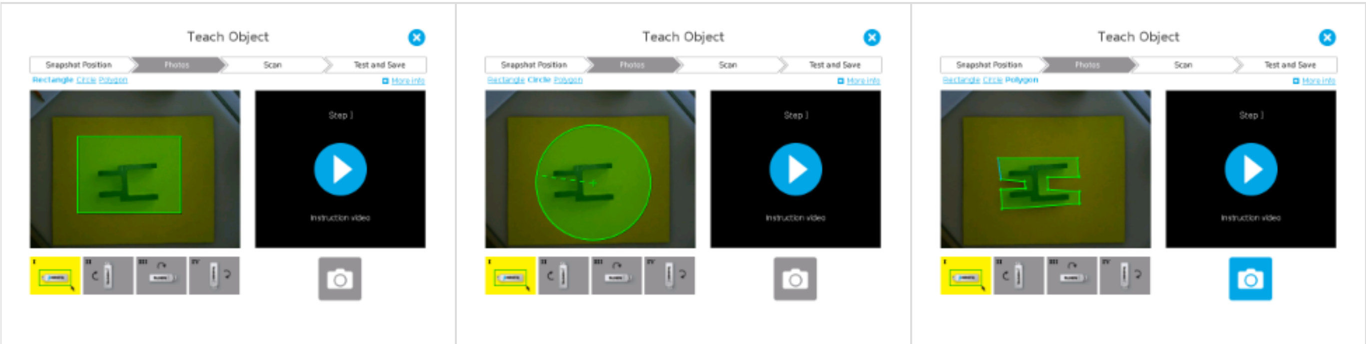


Figure 5.2.1.2: Different area shape to take photos of the object.

- Make sure the area you defined is as close to the part as possible, leaving a margin of uniform background.
- The outlined area will turn from red to green when the area is large enough.

> **Reminder**
> The smallest object dimension must be at least 10% of the field of view. The largest object dimension must be less then 60% of the field of view

> **Instructions**
> Video instructions are available on the teach pendant throughout the **Photos** step. Tap on the play button to view the instructions at each part of the **Photos** step.

- Once the outline has been defined, tap the **Snapshot** logo.
  - When photo is taken, the snapshot will appear on the bottom left.

> **Info**
> If the part has been properly detected, your part will have green and red outlines. If the part has not been recognized, check the guidelines of section 5.1.

- Photos from 2 to 4 is the part on your background with a 90° rotation. Rotate the part and tap the **Snapshot** logo. Do a 90° rotation between each photo.

> **Enlarge Photos**
> Tap on any snapshot taken in the object teaching wizard to enlarge it.

- When all photos of the part are taken, you must verify the part model that has been built by the vision system.
  - Object contours and recognized features outlined with green lines.
  - Features from the model but not on the object in the field of view will be outlined with red lines.

> **Info**
> Green contour should match the object's shape at all time, features within the part may or may not be recognized. Tap on any snapshot in the wizard to enlarge it.

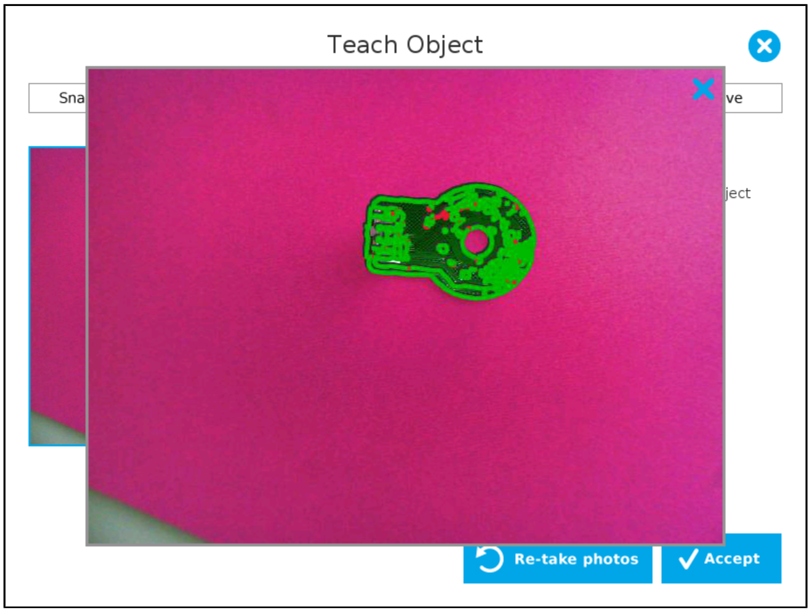


Figure 5.2.1.3: Part model defined by the vision system.

- After the Photo step, the model is shown. If the model suits your part, tap **Accept**. Otherwise tape **Re-take photos**.

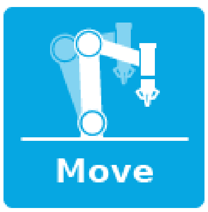
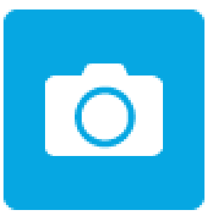
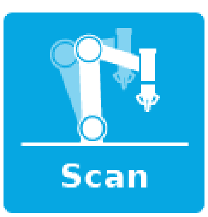
Scan

- You can now take off your high-contrast background and tap **Scan** to begin scanning.

> **Warning**
> Scanning is an automatic process, the robot will move in order to perform calibration. Make sure the robot's work space is clear. You can tap **Cancel** to stop the process. The operator should watch the robot at all time and have the emergency stop button at hand.

- The vision system will run the scanning of your part, taking 9 photos.
- When the process is done, the wizard will switch to the **Test and Save** phase. See Section 5.2.3.

Features

Icon	Feature	Description
	Teach object	Tap to launch the object teaching wizard.
	Choose	Tap to select the snapshot position you want to use.
	Move	Tap and hold to move the robot automatically to the Snapshot Position pose.
	Snapshot	Tap to take a photo of your background or object.
	Re-take photos	Tap to restart the Photos step of the Object Teaching wizard.
	Accept	Tap to accept the photos taken during the Photos step of the Object Teaching wizard.
	Scan	Tap to start the scanning procedure. The robot will move automatically around your object.
	Cancel	Tap to cancel the scanning procedure while it is running.

5.2.2 Parametric Method

When teaching a simple geometry object, it is best to use the parametric method. It builds a model based on parameters of a basic 2D shape (circle, ring, square or rectangle). This method allows the vision system to recognize and locate with high robustness parts that have few distinctive features such as raw material blanks. Usually gives best results than the Automatic method for simple geometry and highly reflective parts.

Choose the geometry that suits the part to detect and define its parameters:

- Circle
- Ring
- Rectangle
- Square

Height
In all cases, the height (h) is the distance between the workplane and the shape. It considers and compensates the thickness of the provided calibration board (roughly 3mm) that was used to calibrate the work plane. Thus, if you calibrated the work plane using a printed version of the calibration board, you must add 3mm to the height of the feature.

Circle

Enter the circle diameter (D) and the height (h) at which the circle is located.

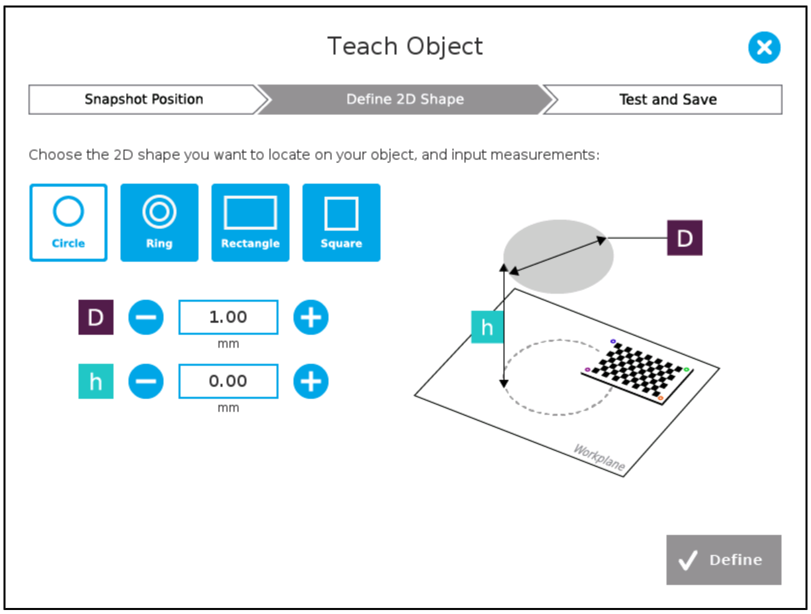


Figure 5.2.2.1: Definition of circle 2D shape.

Ring

Enter the ring outer diameter (D), inner diameter (d) and the height (h) at which the ring is located.

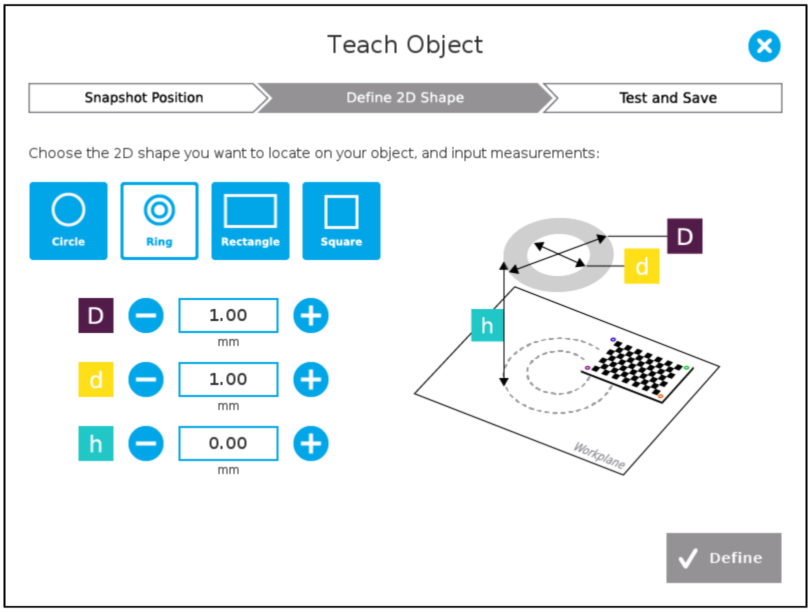


Figure 5.2.2.2: Definition of ring 2D shape.

Rectangle

Enter the rectangle length (l), width (w) and the height (h) at which the rectangle is located.

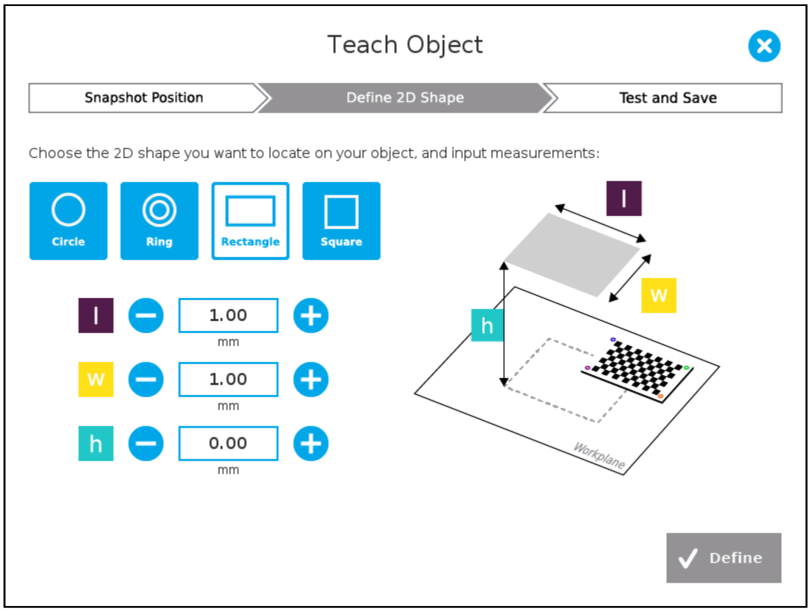


Figure 5.2.2.3: Definition of rectangle 2D shape.

Square

Enter the square length (l) and the height (h) at which the square is located.

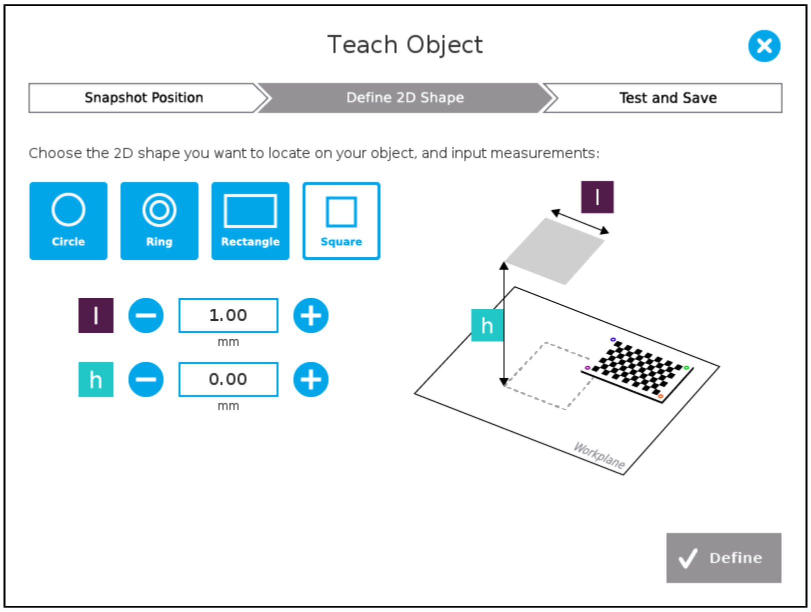


Figure 5.2.2.4: Definition of square 2D shape.

When the process is done, the wizard will switch to the **Test and Save** phase. See Section 5.2.3.

5.2.3 Test and Save

Place your part in the field of view and test locating with the run-time environment. Tap **Test locating object**:

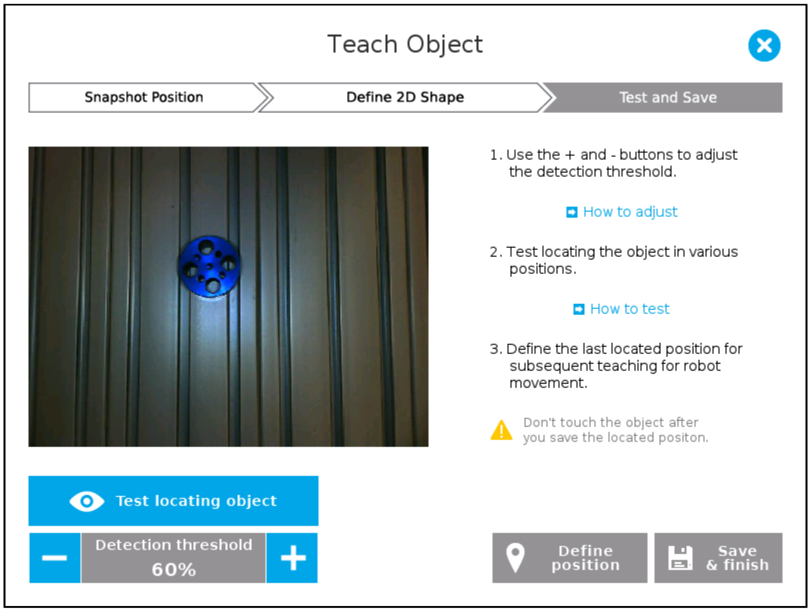


Figure 5.2.3.1: Test and Save.

- If the object is found, you will see the part outlined with the detection score (%).

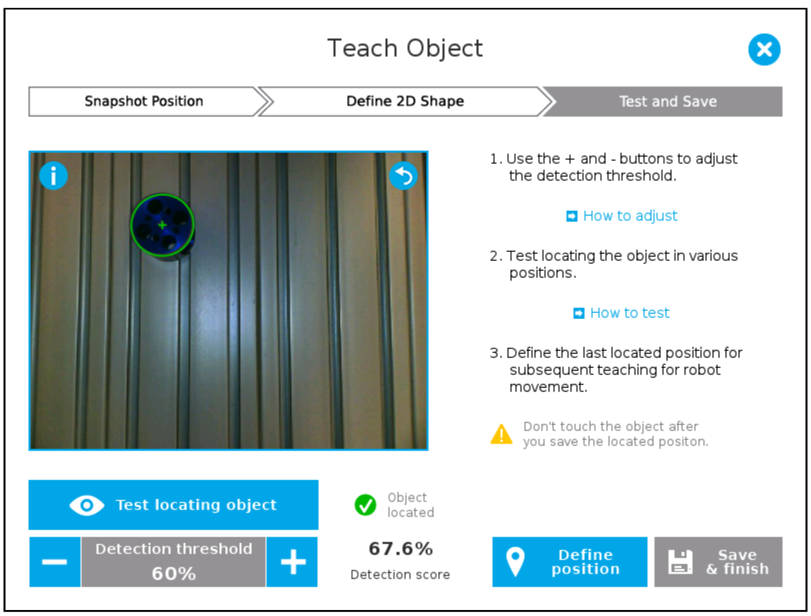


Figure 5.2.3.2: Object found with detection score.

- If no object is found, a message saying the object is not found will appear.

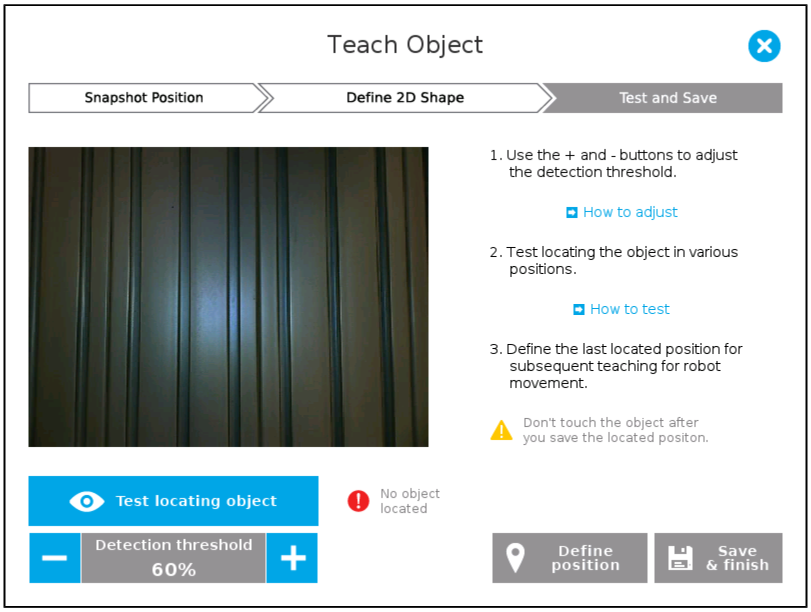


Figure 5.2.3.3: No object found.

When testing the localization:

- Part contour and recognized features will be outlined with green lines.
- Features from the model that are not spotted on the object will be outlined with red lines.

> **Info**
> When doing the localization test, place your part all over the work plane. Due to perspective effects, the part feature may not be recognized at some points. If you have an important feature to be match for your application (a hole for example), make sure it is found everywhere. Again, green contour should match at all time.

> **False Detection**
> To avoid false detection, remove the part from the work plane, decrease the detection threshold to 0% and try to locate the part. If false detection may occur on your work plane, you will see an object detected with the detection score. Increase the detection threshold above this score to avoid false detection.

- Try all areas of the work plane area on which the part may be located. Adjust the detection threshold properly for your part and run-time environment.
- Adjust the detection threshold with the **+** and **-** buttons.

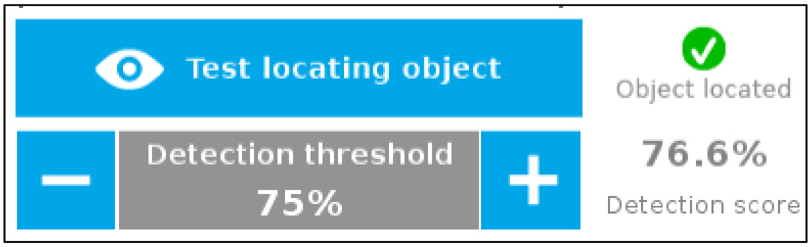


Figure 5.2.3.4: Detection threshold adjustment.

Set the detection threshold at the highest value possible so the vision system detects the part on the whole work plane. Tap Test locating object to test the threshold.

- This ensures the best robustness regarding the part detection throughout the work plane. If it is not possible to define such a success rate the following should be considered :
  - Redefine the Cam Locate node (go through the Teach object wizard again), make sure there are no, or the least possible, reflections.
  - Check the guidelines of section 5.1.

Edit threshold
After completing the object teaching wizard, it is possible to edit the detection threshold. To do so, select the Camera Locate node and go in the Command tab. Click on on **Test/Modify** to edit the threshold and/or modify the part's position.

- Once you are done with the test and adjustment, tap the **Define position** button.

Note
Do not move your part after saving position, the relative movements you will program afterwards in your robot program are relative to that position, see section 6.1.

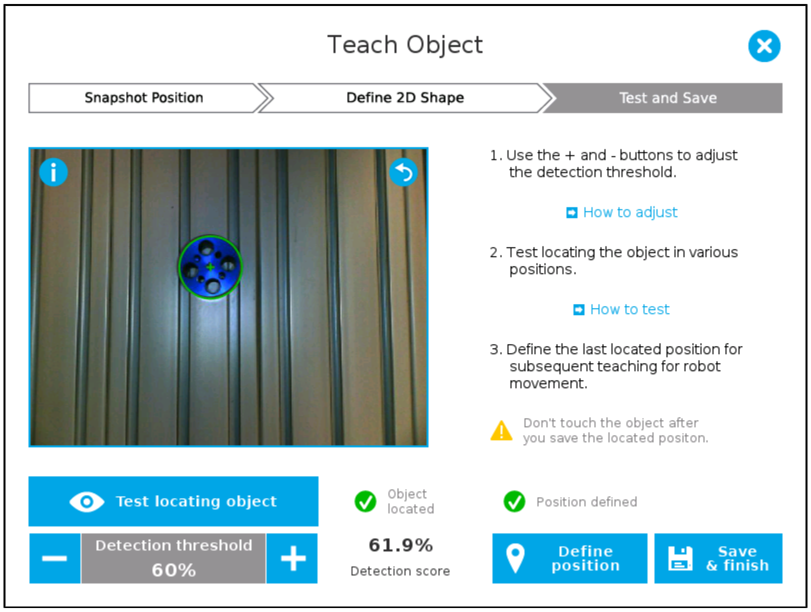
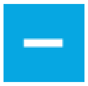


Figure 5.2.3.5: Position defined.

- Once position is saved, tap the **Save & finish** button
- When you are done with the teaching process, the Camera Locate node will show you a snapshot of your saved part. You can tap **Reset** to redefine completely. You can tap **Test / Modify** to modify the detection threshold or both the threshold and the saved object position.

Features

Icon	Feature	Description
	Test locating object	Tap to test locating an object, the Vision System will search the field of view for your object.
	Back	After testing a part location, tap to return to the camera's output image.
	Detection Threshold -	Tap to lower the Detection Threshold setting.
	Detection Threshold +	Tap to increase the Detection Threshold setting.
	Object located	After testing the object location, icon shown when an object is located. Detection score will appear.
	No object located	After testing the object location, icon shown when no object is located.
	Define position	Tap to save the part's position for programming linear move (MoveL) relative to the part's location.
	Position defined	Icon shown when the position is defined.
	Save & finish	Tap to save the detection threshold and finish the wizard.
	Test / Modify	Tap to access the Test and Modify wizard. It allows you to modify the detection threshold and the saved part position.
	Reset	Tap to reset the whole process of the Object Teaching wizard.

6. Programming with the Camera Locate Node

Fast Cycle Time

If the ambient lighting is stable during run-time, you can enable the fast cycle time configuration. To do so, go in **Installation** from the program. Choose **Ca mera** and go in **Configurations**.

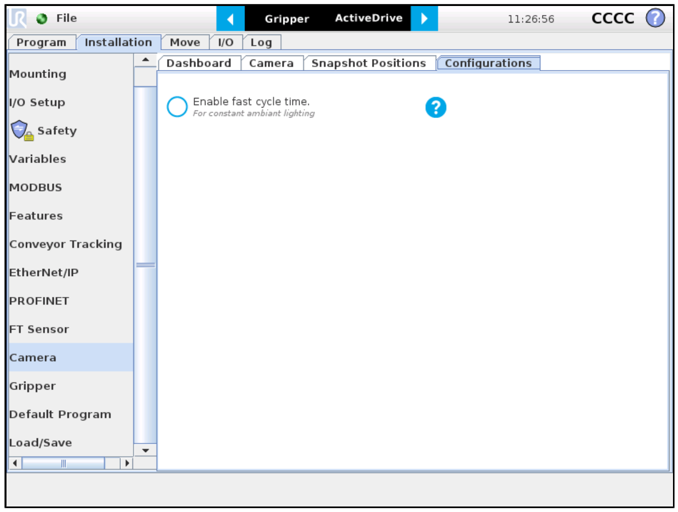
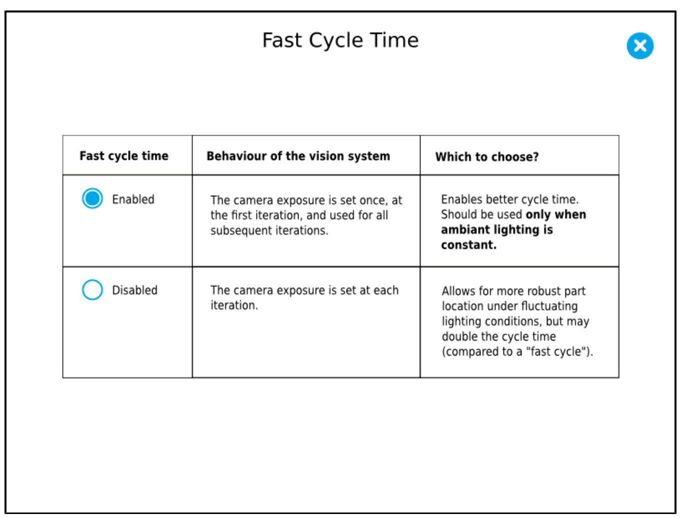


Figure 6.1: Enable fast cycle time when ambient lighting is fixed.

By enabling the fast cycle time configuration, the camera exposure will be set the first time the program enters a Camera Locate node - at run-time. For all other Camera Locate nodes, the camera will keep the exposure settings from the first run. This reduces the cycle time by half as opposed to not enabling the fast cycle time configuration.



Fast cycle time	Behaviour of the vision system	Which to choose?
Enabled	The camera exposure is set once, at the first iteration, and used for all subsequent iterations.	Enables better cycle time. Should be used **only when ambiant lighting is constant.**
Disabled	The camera exposure is set at each iteration.	Allows for more robust part location under fluctuating lighting conditions, but may double the cycle time (compared to a "fast cycle").

Figure 6.2: Fast cycle time configuration.

Fast Cycle Time
Enable the fast cycle time configuration **only if the external ambient lighting is constant**.

Programming

The first thing to do after completing the object teaching is to add a Move node to the snapshot position. When you exit the object teaching wizard, the robot arm is already in the Snapshot position location. You can simply add a *MoveJ* command before the Camera Locate node and set it to the location the robot arm is at (see *Snapshot_pos_1* from Figure 6.1.1).

> **Snapshot position**
> Make sure the robot arm is moved to the snapshot position before the Camera Locate node in the robot program.

The Camera Locate node acts as an "if" statement. If the taught object is detected by the camera, the robot program will enter in the Camera Locate node and execute all the command lines within it.

After teaching the object within the Camera Locate node, you may continue the programming by using either a linear move (MoveL) with the snapshot position's variable as feature or the object_location pose. It is also possible to edit the detection threshold or the saved object position after the Teach Object wizard.

- Refer to Section 6.1 to program a robot motion with a linear move (MoveL) with the snapshot position's variable as feature. A template of this type of program is provided. This allows to perform robot motion relative to the object detected at run time.
- Refer to Section 6.2 to use the object_location pose to program the robot motion - for advanced use.
- Refer to Section 6.3 to edit the detection threshold and/or the saved object position.

> **Cycle Time**
> The Camera Locate node cycle time is influenced by the background complexity, the object's features complexity and the number of objects on the work plane.
>
> To reduce the Camera Locate cycle time, consider the following:
>
> - Have the least possible objects and object types on your work plane at run time.
> - If your object has many detailed features, you can teach a drawing of it with simplified features or teach only one area of the object.
> - Have a diffuse ambient lighting, avoiding high light intensity spots on the work plane.

6.1 Linear Move with Feature - Pick and Place Template

Info
The URCaps installation will provide you with a template program, **template_vision.urp**, that can be found in the program folder. Figure 6.1.1 below shows this template. This section guides you through the process of doing a similar program.

Once the Teach Object wizard is completed, you saved the last position of your part. The object position variable, named after the snapshot position, now contains the reference frame of the object in this saved position. Each time the Camera Locate node localizes an object, it updates that feature variable's frame with the new detected object's position and orientation. That feature is named according to the feature name you chose during the snapshot position definition.

Saved position
The saved part position from the Teach Object wizard or the Test/Save wizard is the position of the part to be used for the relative robot motion programming. Once the position is saved, do not move the object to ensure proper robot motion programming within the Camera Locate node.

You can use that reference feature inside the Camera Locate node within Move commands of the robot. To do so:

- Insert a Move node.
- In that node, go to the Command tab.
- Select MoveL.
- Select the appropriate feature (your Snapshot Position / Feature name).

Every waypoints inserted within that MoveL node will be relative to the feature updated by the Camera Locate. Without moving your part, teach your waypoints according to it's position.

Object orientation
If you want your relative motion not to consider the object orientation, check the **Ignore object orientation** option from the Camera Locate node Command tab. This way, the MoveL will consider the part's position, but not its orientation. It can be used, for instance, to pick a part that is circular.

When you are done with the movements relative to the part, you can insert another Move node, selecting a movement that is not relative, but absolute (base frame), and do normal movements.

This process will give you:

- A set of MoveL movements relative to the part orientation.
- A set of MoveJ, MoveL or MoveP movements relative to the absolute base frame.

In short, the template program in Figure 5.3.1 will move to the Snapshot Position, search for the part, do a set of movement relative to the part orientation, then do a set of movement relative to the robot base. It is provided and installed with the Camera Locate URCap.

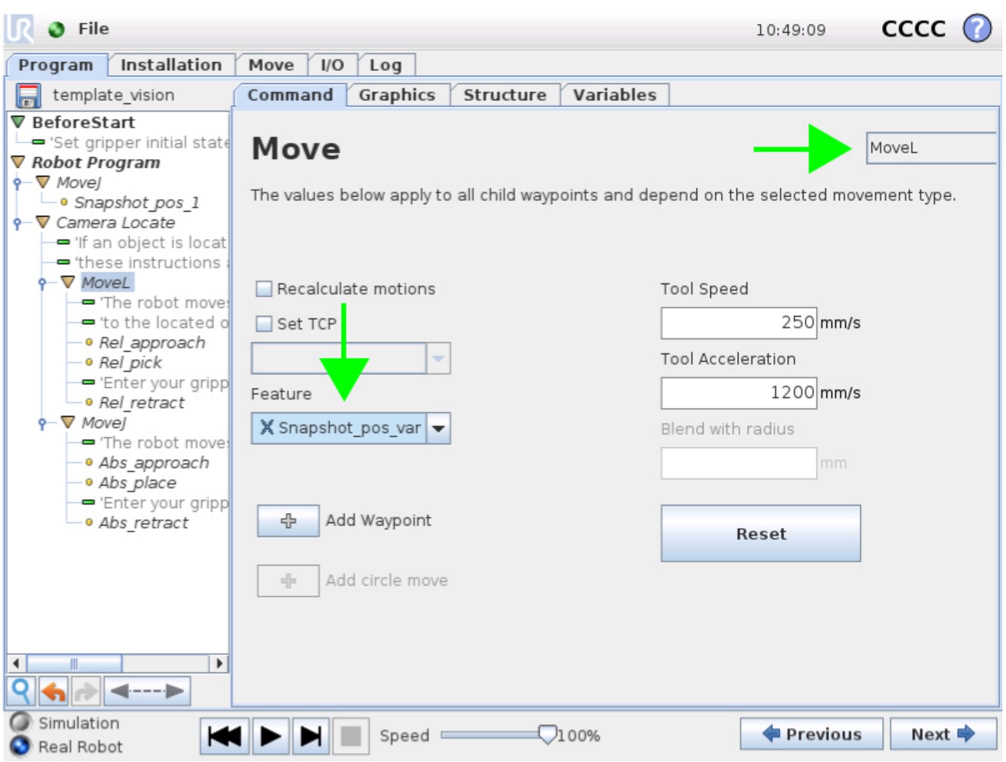


Figure 6.1.1: Template program for a Camera Locate pick & place application.

6.2 object_location pose

Once a snapshot position is defined, the work plane used for the calibration gets its own coordinate system, regardless of its orientation. This coordinate system is shown in Figure 6.2.1.

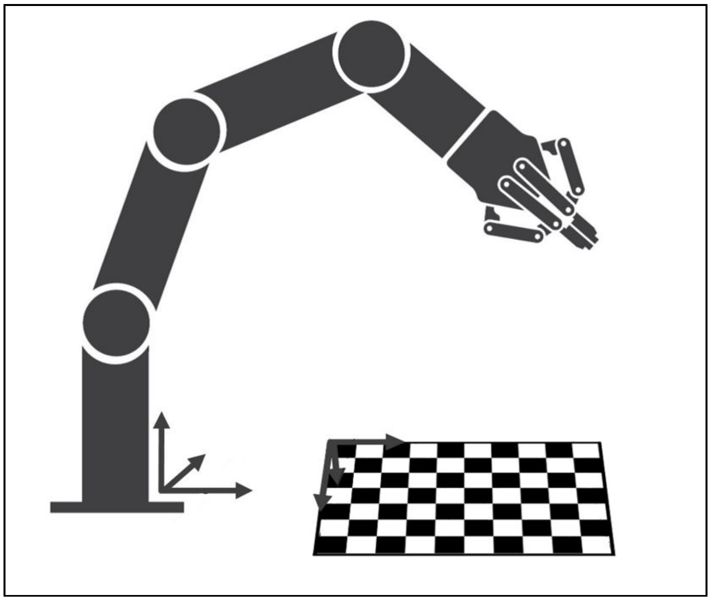


Figure 6.2.1: Work plane reference frame.

The camera will detect an object on the work plane and find its X-Y position, as well as its Z-orientation in the work plane's coordinate system (Figure 6.2.1). Thus, a detected object is always laid flat (parallel) to the work plane. It is possible to use the **object_location** pose, which is a variable containing the detected part's pose (p[x, y, z, x rotation, y rotation, z rotation]) in the robot's base reference frame. This variable is updated each time the program goes within a Camera Locate node, thus every time a part is detected, regardless of how many Camera Locate nodes are in the program. The object_location pose is relative to the robot's base frame.

Part's frame
object_location is a variable containing the detected part's position and orientation relative to the base reference frame. The orientation is always parallel to the work plane on which the calibration has been performed. Thus, the part's X and Y axes are always parallel to the work plane. The Z axis is always normal to the work plane and points downwards from it, into the work plane (refer to Figure 6.2.2).

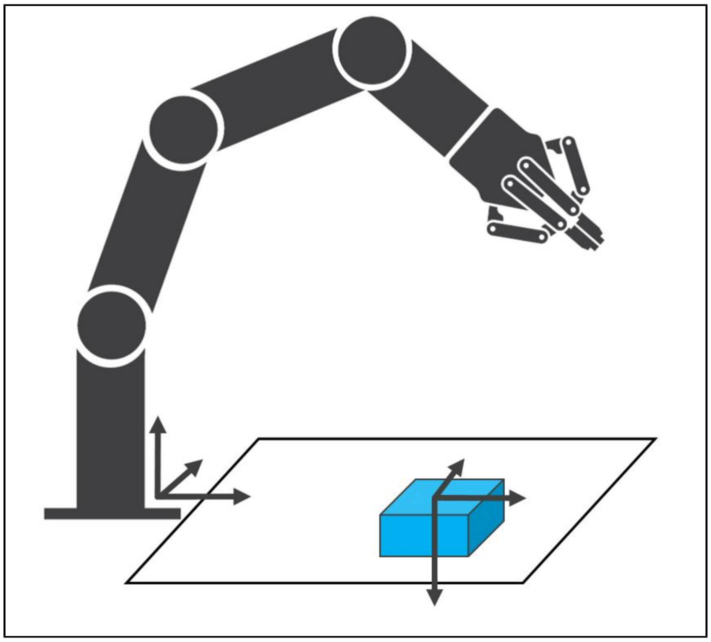


Figure 6.2.2: object_location pose on the work plane used for the calibration.

object_location is a variable with the pose structure (x, y, z, x rotation, y rotation, z rotation):

x : x position of the object detected, relative to the robot's base reference frame.

y : y position of the object detected, relative to the robot's base reference frame.

z : z position of the object detected, relative to the robot's base reference frame.

x rotation: x rotation from the robot's base frame to the detected object feature reference frame. The part's X axis is parallel to the work plane on which the calibration has been performed.

y rotation: y rotation from the robot's base frame to the detected object feature reference frame. The part's Y axis is parallel to the work plane on which the calibration has been performed.

z rotation: z rotation from the robot's base frame to the detected object feature reference frame. The part's Z axis is normal to the work plane on which the calibration has been performed, points downwards from it, into the work plane.

> If you move the robot's TCP to the object_location pose, the TCP will go and point the object on the work plane. The height value of the part on the work plane should not be taken into account - the TCP might be directly on the object when moving it to the object_location pose.

Program Example

The program examples below show how to use the object_location pose variable.The first one simply moves the robot so that the TCP goes directly on the detected object. Make sure the TCP is set properly to avoid collisions.

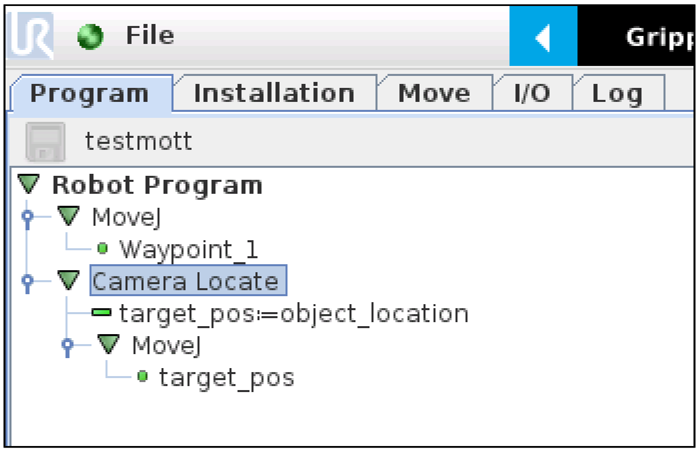


Figure 6.2.3: Program example - place the TCP on the detected object.

The second example moves the robot so that the TCP goes 20cm above the detected object. This is in the case of an horizontal plane.

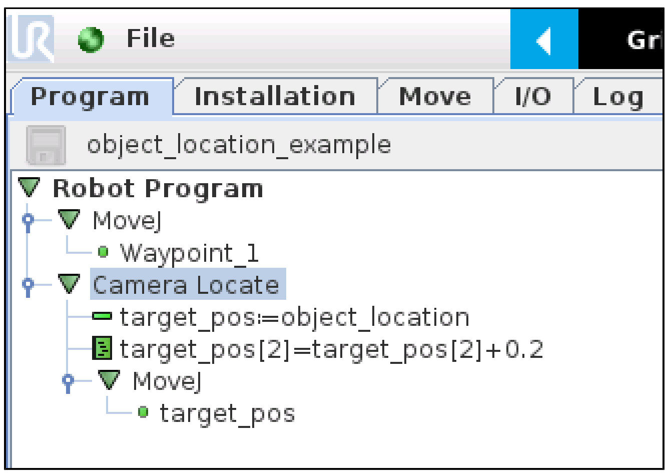


Figure 6.2.4: Program example - place the TCP 20cm above the detected object, in case of an horizontal plane.

6.3 Edit Detection Threshold and Part Location

It is possible to edit both the detection threshold and the object location after the Teach object wizard has been completed. To do so, select the Cam Locate node, go in the Command tab and tap Test/Edit. The wizard as shown on Figure 6.3.1 will appear.

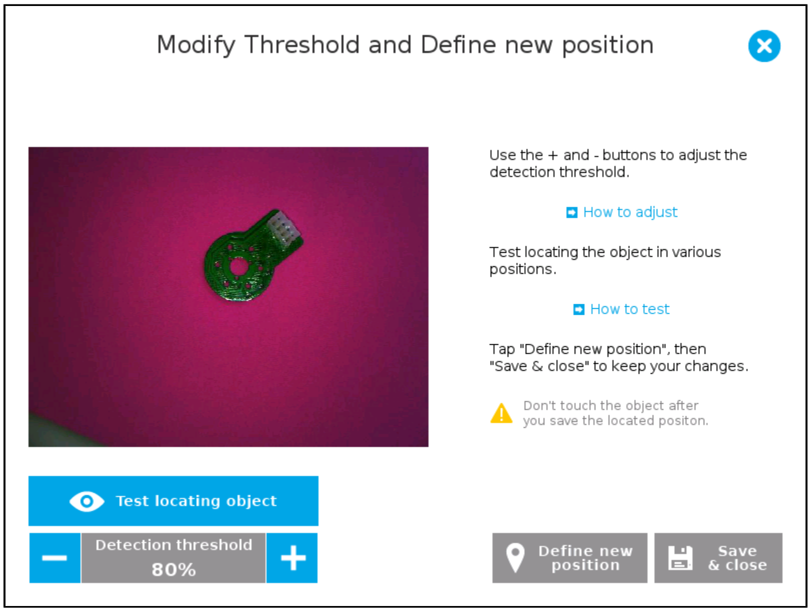


Figure 6.3.1: Modify Threshold and Define new position wizard.

- To modify the saved object position, place the object in the desired position. Test is with the Test locating object button and, when in the desired position, tap Define new position. The position is saved. Tap Save & close to exit the wizard. This also saves the threshold.
- To modify only the detection threshold, modify it and test it. Once it is at the required value, tap Save & close. This does not modify the object position previously saved.
- To modify both the threshold and the object location, adjust the threshold, place the object in the desired position and test is with the Test locating object button. Once in the desired position, tap Define new position. The position is saved. Tap Save & close to save the threshold.

6.4 Camera Locate node at a variable snapshot position

During a robot program, the robot must be at the snapshot position before entering the Camera Locate node. If it is not in the right position, a pop-up will appear, preventing the camera from taking a snapshot from the wrong position. This is to ensure good precision since the work plane has been previously calibrated for this snapshot position.

In some cases, it is helpful to move the robot to a variable position to enter a Camera Locate node. For instance, it can also used to teach only one snapshot position and object to manage parts in stacked trays. In order to do so, allow the robot to be in a different position that the original snapshot position by entering the script command:

ignore_snapshot_position = True

You also need to edit the **snapshot_position_offset** pose variable. This variable contains the pose offset between the original saved snapshot position and the one used in the program .

The example from Figure 6.4.1 shows a program using a Camera Locate node to manage parts in stacked trays.

- The script command in the BeforeStart section allows the camera not to be in the exact snapshot position when entering a Camera Locate node.
- The pose at which the robot enters the Camera Locate node is calculated knowing how many trays are stacked.
- The **snapshot_position_offset** is calculated accordingly in order for the Wrist Camera to consider the pose offset from the original snapshot position.

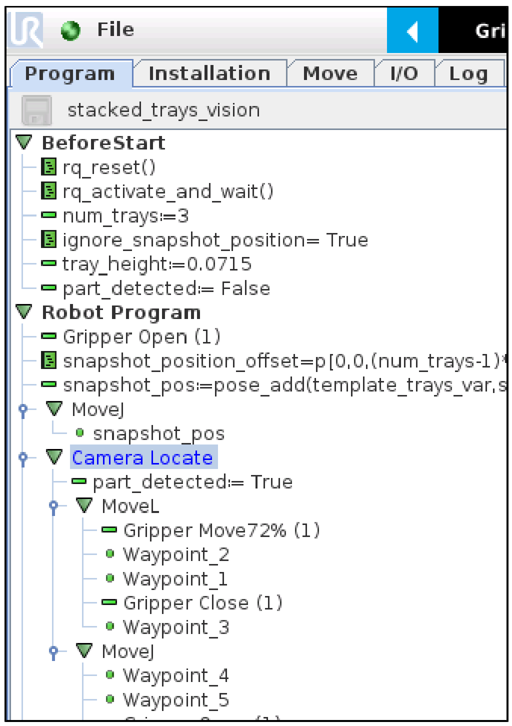


Figure 6.4.1: Program example.

ignore_snapshot_position = True
When using this method, make sure the work plane has the same orientation and distance regarding the position of the camera before a Camera Locate node. Using a variable and relative snapshot position may decrease the precision, as the work plane can be slightly different depending on where the calibration has been performed. Be aware of this when programming a Camera Locate node relative to another one.

7. Specifications

Reminder
The following manual uses the metric system, unless specified, **all dimensions are in millimeters**.

The following sub-sections provide data on the various specifications for the Robotiq 2-Finger 85 and 140 Adaptive Grippers.

- Section 7.1 mechanical specifications of the Wrist Camera:
    - Dimensions;
    - Maximum load;
    - Center of mass;
    - Moment of inertia.
- Section 7.2 electrical rating & performance specifications of the Wrist Camera:
    - Electrical supply;
    - Resolution;
    - FPS.
- Section 7.3 Vision System specifications:
    - Field of view;
    - Part size.

7.1 Mechanical Specifications of Wrist Camera

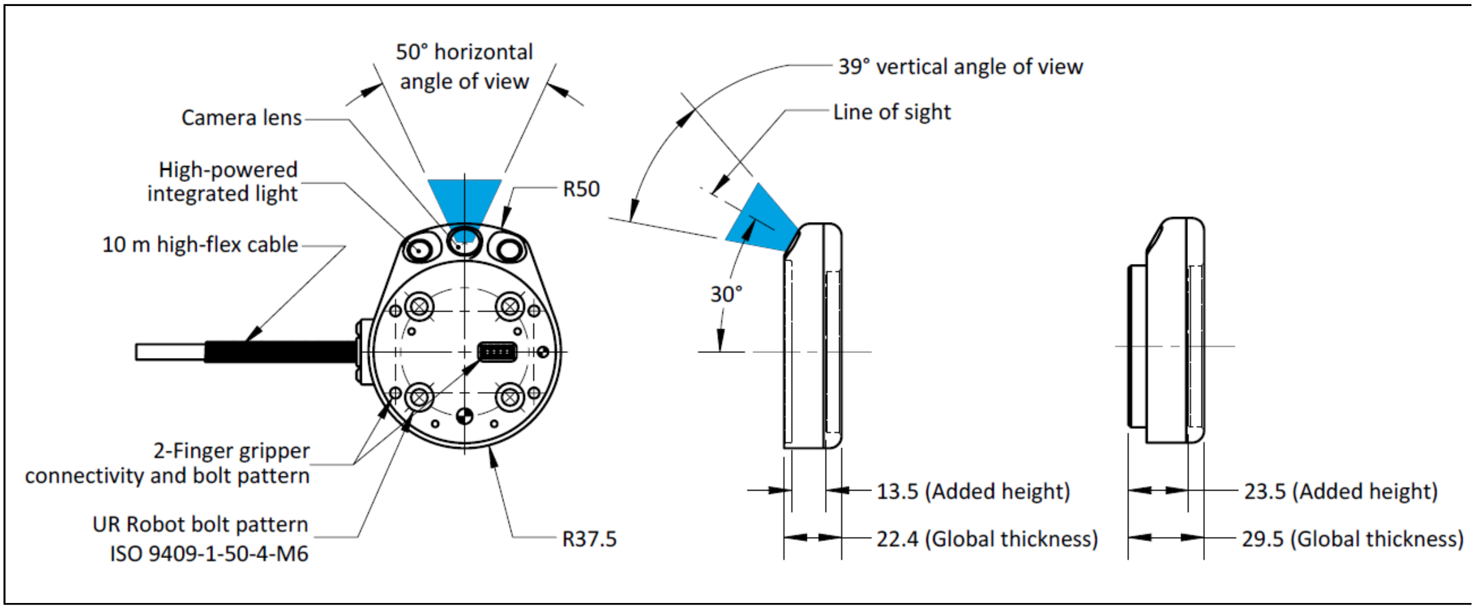


Figure 7.1.1 : Wrist Camera's dimensions.

Specification	Value	
Maximum load	10 kg	40 Nm
Weight (without tool plate)	160 g	
Weight (with tool plate)	230 g	
Added height (without tool plate, for use with 2-Finger Gripper)	13.5 mm	
Global thickness (without tool plate)	22.4 mm	
Added height (with tool plate)	23.5 mm	
Global thickness (with tool plate)	29.5 mm	

Table 7.1.1 : Wrist Camera's mechanical specifications.

Photographic sensor
Respecting Universal Robots's axes system, the photographic sensor's is located at [0mm; 35.7mm; -0.1mm] of the tool flange on which the camera is mounted. The line of sight passes through this point and is at 30° from the Z-axis.

7.1.1 Center of Mass and Moment of Inertia

The coordinate system used to calculate the moment of inertia and center of mass of the Wrist Camera is the base of the Camera which correspond to the UR tool flange reference [0,0,0].

Here is the approximate position for the center of mass. It has been calculated for the camera itself and for combinations with other Robotiq products. The camera's tool plate is included when the gripper is not mounted on the Wrist Camera.

Combination	x (mm)	y (mm)	z (mm)	Mass (grams)
-	0	5	9	230
FT 300	0	2	30	530
2-Finger 85	0	1	58	975
2-Finger 140	0	1	66	1040
FT 300 and 2-Finger 85	0	1	77	1275
FT 300 and 2-Finger 140	0	1	85	1340

Here is the approximate moment of inertia matrix for the Wrist Camera:

Inertia Matrix			Metric value (kg * mm^2)			Imperial value (lb * in^2)		
Ixx	Ixy	Ixz	111	0	0	0.38	0	0
Iyx	Iyy	Iyz	0	70	3	0	0.24	0.01
Izx	Izy	Izz	0	3	165	0	0.01	0.56

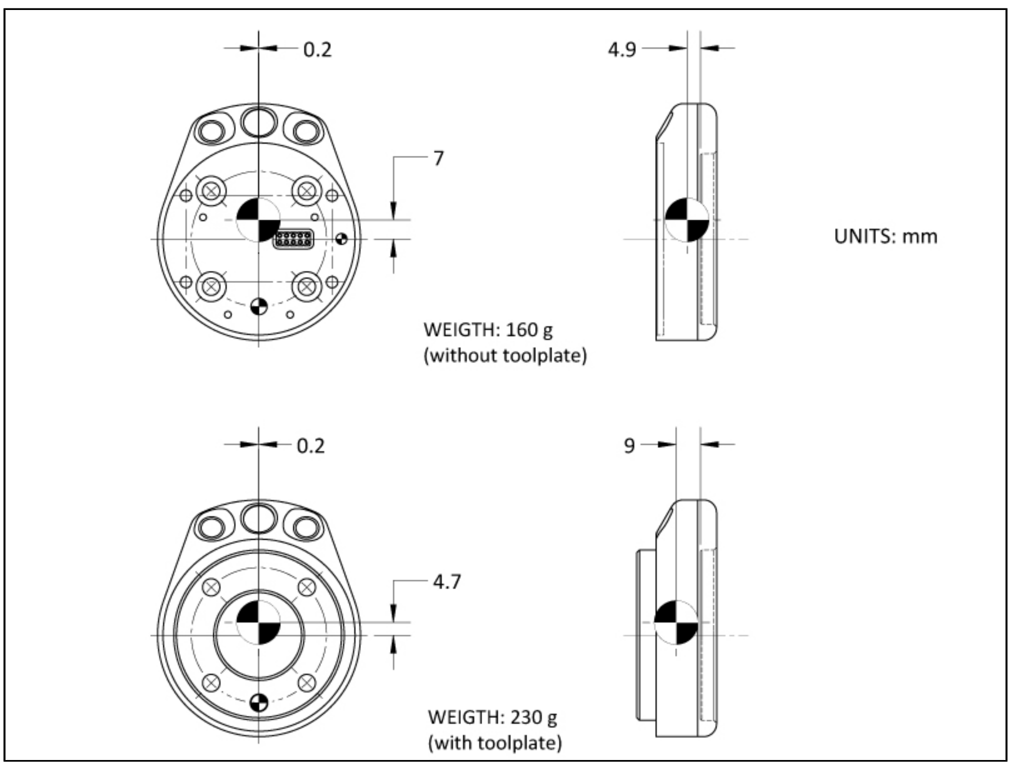


Figure 7.1.1.1: Center of Mass with and without the toolplate.

7.2 Electrical rating & performance of Wrist Camera

Robotiq recommends you supply the Wrist Camera from the Universal Robots controller power supply as shown in section 3.5, if for any reasons you cannot do so, here are the electrical specifications of the Camera:

Specification	Value
Operating supply voltage	24 V DC ±20%
Quiescent power (minimum power consumption)	1 W
Maximum power	22 W
Communication interface	USB 2.0

Here are the Wrist Camera's specifications :

Specification	Value
Maximum resolution	5 Mpx at 2 fps (2560 X 1920)
Maximum frame rate	30 fps at 0.3 Mpx (640 X 480)
Active array size	2592 X 1944
Focus range	70 mm to infinity
Integrated lighting	6 LED diffuse white light
Autofocus technology	Liquid lense

7.3 Vision System Specifications

Accuracy

The accuracy of the vision system is as described in the table below and depends on the robot model used. It is valid for the area where the calibration board was located during the calibration process.

Robot Model	Accuracy
UR3	+/- 2mm
UR5	+/- 3mm
UR10	+/- 3mm

Table 7.3.1: Accuracy of the vision system.

Calibration board position

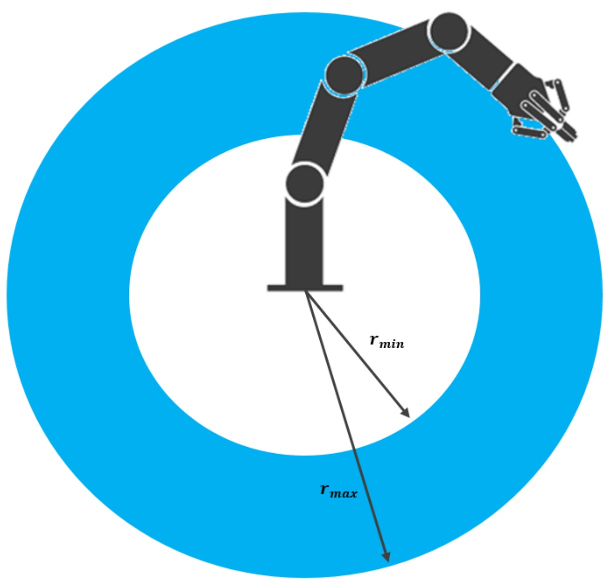


Figure 7.3.1 : Calibration board position.

Specification	Value		
	UR3	UR5	UR10
Maximum board distance (cm)	26	34	42
Minimum board distance (cm)	42	70	98

Tip
Snapshot Position will determine the field of view, notice that the calibration step position does not have to be the same as Snapshot position. Thus, you can have a small field of view, then move back for calibration step.

Field of view

Specification	Value		
	UR3	UR5	UR10
Maximum field of view (cm)	36 x 27	64 x 48	100 x 75
Minimum field of view (cm)	10 x 7.5	10 x 7.5	10 x 7.5

Info
Field of view is (FoV) determined by Snapshot position. To get the minimum FoV, the camera must be placed at 7 cm above the work plane.

Part dimensions

The maximum part size that can be detected by the Wrist Camera is 60% field of view's dimension. The minimum is 10%, no matter the robot or the field of view size.

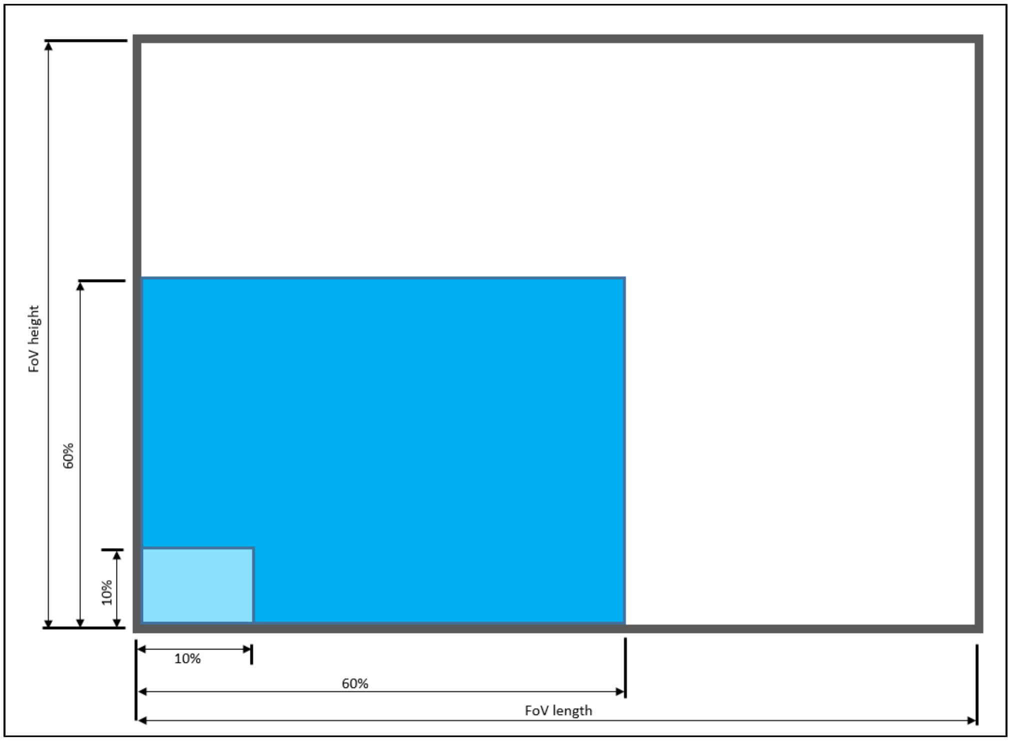


Figure 7.3.2 : Maximum and minimum part size.

The part must not be higher than its smallest dimension (width or length) : maximum of 1:1 ratio.

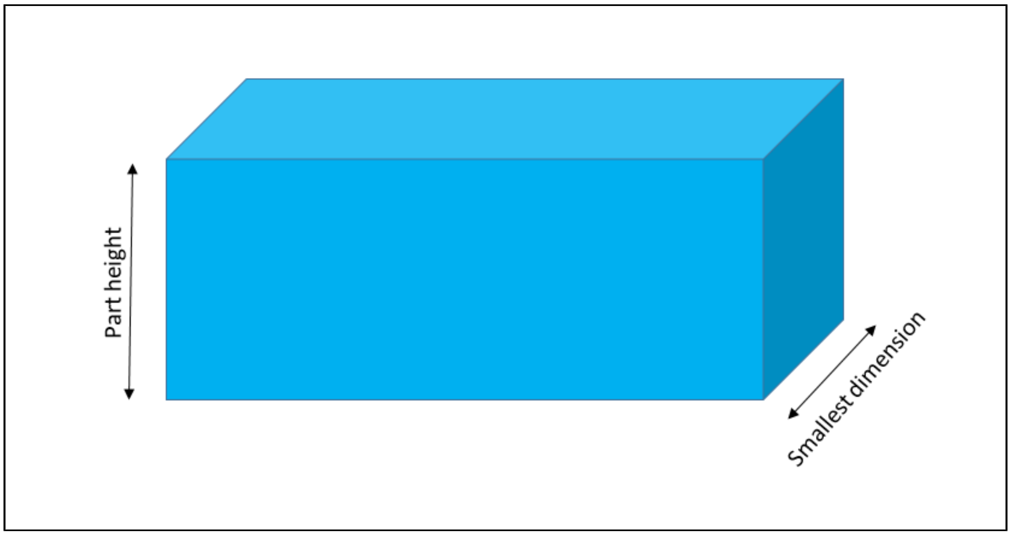


Figure 7.3.3 : Maximum part height.

Info
Part height ratio is taken between the maximum part height at any point and the minimum dimension present on part contour, width or length.

Background contrast

To ensure a good model and part detection from the Vision system, you should use a background that has a high color contrast with the part to be detected. You must choose colors that are apart horizontally on the HSV cone shown below. Therefore, a change in value (intensity) only does not represent a good contrast. There has to be a great difference in hue and saturation to obtain a good object model from the object teaching wizard. You can use either the yellow or pink side of the colored background provided with the camera kit. If required, use a different colored background to teach your part.

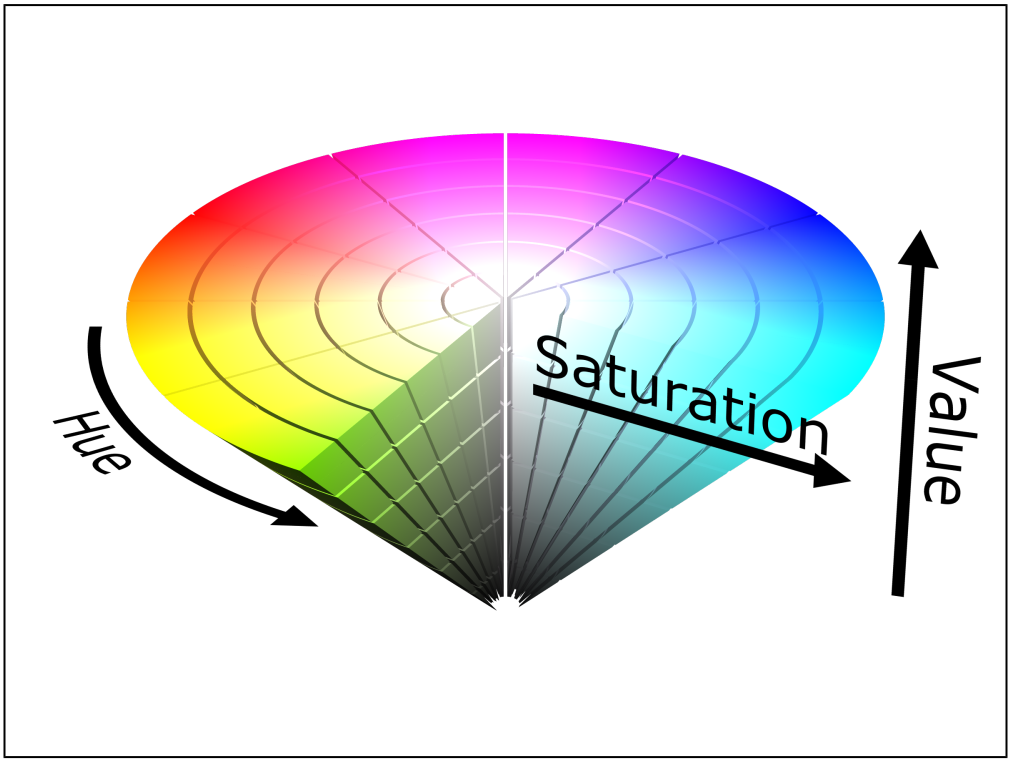


Figure 7.3.4 : HSV color cone.

8. Maintenance

Wrist Camera maintenance

The Camera does not need any maintenance. Make sure that the lens is kept free from liquid or dust at all time. Robotiq recommends you use the provided bag with your camera along with alcohol to clean the lens.

Background clean

You work plane should be kept as constant as possible. Depending on your application, you should occasionally clean the work plane.

Note
If your work plane background changes after the object teaching process (at run-time), object localization performance could decrease.

Tip
The Vision System is able to compensate for some differences during run-time. Adjust the Detection Threshold as explained in section 5.2.3 to have a reliable object localization.

9. Spare Parts, Kits and Accessories

Spare parts, kits and accessories list :

The following list is up to date at print time and is subject to change, check online for updates.

Info
Unless specified, screws, dowel pins and other hardware are included only for the Gripper side, never for the robot side.

Item	Ordering Number
Wrist Camera Kit for *Universal Robots* . Includes Wrist Camera, calibration board, tool plate for UR, USB memory stick, license and hub and all hardware.	RWC-UR-KIT
Replacement Wrist Camera. Includes 10 m pigtail cable.	RWC-CAM-001
Wrist Camera tool plate for ISO 9409-1-50-4M6 pattern (*Universal Robots*).	RWC-TOOL-062
Replacement calibration board.	ACC-CALIB-BOARD
Replacement 10m High-Flex pigtail cable for Wrist Camera.	CBL-COM-2069-10-HF
4 ports USB 2.0 hub splitter	ACC-USB-4-HUB
16 Gig USB stick	ACC-USB-16G
Replacement software licence USB dongle for Wrist Camera	ACC-USB-DONGLE
Universal Robots Screw Kit for Wrist Camera	ACC-SCREW-KIT-RWC-UR

10. Troubleshooting

Versions
To view the Vision server, Camera URCap and Camera firmware versions, proceed with the following :

- From a Robot program, go in the Installation tab.
- Choose Camera
- Go in the About tab.

The versions will appear. Make sure they are the latest release and that they are both updated simultaneously.

Note
More details to come.

10.1 LED status

LED status	Description	Solutions
Off	The Camera is not powered.	Check the Camera's power supply and electrical setup (Section 3.5).
Solid red	No fault but the Camera is not communicating.	Start or do a stop/start cycle of the Vision server. To do so, go in the Installation tab, choose Camera and then the Camera tab. Click on Start camera to start the Vision server. The output image will appear and the LED will turn blue. Check the USB cable connection and the software package versions.
Solid blue and red at the same time	The Camera is in fault or booting.	Wait for the booting process to be completed. If the LED stays solid blue and red, disconnect the Camera's USB cable and power cycle it. The red LED should be solid red. Reconnect the USB cable. The LED should turn solid blue when communication is established with the Vision server (click on Start camera from the Installation tab).
Blinking blue and red	Major fault : • Camera's input voltage is not sufficient • Temperature is greater than 70°C	• Check the power supply to make sure it is 24 V DC +/- 10%. • The Wrist Camera should not operate at a temperature higher than 50°C.
Solid blue	Not fault and communicating.	-

11. Warranty & patent

Robotiq warrants the Wrist Camera and Vision System against defects in material and workmanship for a period of one year from the date of shipping from Robotiq when utilized as intended. Robotiq also warrants that this equipment will meet applicable specifications under normal use.

Warranty applies under the following conditions:

- Usage respects the operating and storage conditions specified in Section 3.3
- Proper installation of the Camera specified in Section 3 and the following subsections.
- Usage under normal one-shift operation (40h a week)
- Usage respects maintenance specified in Section 8.
- Usage respects recommended payload and forces specified in Section 7.1.

During the warranty period, Robotiq will repair or replace any defective Wrist Camera, as well as verify and adjust the Camera free of charge if the equipment should need to be repaired or if the original adjustment is erroneous. If the equipment is sent back for verification during the warranty period and found to meet all published specifications, Robotiq will charge standard verification fees.

The unit is considered defective when at least one of the following conditions occurs :

- The Camera does not output any image;
- The Camera feedback necessary for the robot program is not accessible;
- The Vision System USB memory, USB hub or USB dongle are inoperable;

Caution
The warranty will become null and void if the :

- Unit has been tampered with, repaired or worked on by unauthorized individuals.
- Warranty sticker has been removed.
- Screws, other than as explained in this guide, have been removed.
- Unit has been opened other than as explained in this guide.
- Unit serial number has been altered, erased, or removed.
- Unit has been misused, neglected, or damaged by accident.

This warranty is in lieu of all other warranties expressed, implied, or statutory, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. In no event shall Robotiq be liable for special, incidental, or consequential damages.

Robotiq shall not be liable for damages resulting from the use of the Robotiq Wrist Camera or Robotiq Vision System, nor shall Robotiq be responsible for any failure in the performance of other items to which the Wrist Camera is connected or the operation of any system of which the Vision System may be a part.

Exclusions
This warranty excludes failure resulting from: improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the Wrist Camera, the Vision System or other factors beyond Robotiq's control.

Robotiq reserves the right to make changes in the design or construction of any of its products at any time without incurring any obligation to make any changes whatsoever on units already purchased.

12. Contact

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DoF

Where automation Pros come to share their know-how and get answers.

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A. Harmonized standards, declarations and certificates

Note
Details coming soon