MIRAI
Initial Setup Guide

How to set up MIRAI and start training

VERSION 16.1.0

micropsi
industries

Contents

Using the MIRAI Initial Setup Guide

Hello!

We have put together this MIRAI Initial Setup Guide to ideally help you:

- ☑ Build your initial MIRAI Setup
- ☑ Perform your initial MIRAI skill trainings (with tips and best practices!)
- ☑ Troubleshoot and improve your MIRAI skill over time
- ☑ Provide you with other key information related to MIRAI

⚠ NOTE

This guide is constantly being updated.
You can find the latest version in our Support Center (linked below).

Once you have had several robot training sessions with MIRAI and discover that you need troubleshooting tips or require details which are not covered in this initial setup guide, you can refer to these resources:

User Manual for MIRAI Training

Micropsi Industries Support Center (EN)

Micropsi Industries YouTube Channel

Alternatively, you can also:

- Get in touch with your Micropsi representative.
- Submit a support request through the Support Center (linked above).
- Call the United States Technical Support Team at (978) 584-4505 (Monday to Friday from 08:00am to 5:00pm (PST)).

We'd be more than happy to assist you with all things MIRAI.

Happy training!

- Your Micropsi Team

Getting to Know MIRAI

What's in Your MIRAI Kit

Your MIRAI Kit contains the following components:

- ☐ MIRAI robot controller: A Linux-based OS PC which saves your MIRAI skills, uploads to and stores data in the cloud to enable skill training and controls the robot when a MIRAI execution is taking place.[1]
- ☐ Camera components: These include the camera(/s), lenses, camera mount, and ring light(/s) which will serve as the "eyes" of your robot.[2]
- ☐ Android-based tablet w/ the MIRAI Training App: This allows you to interact (i.e., create, train, test and refine skills) with your MIRAI Controller.
- ☐ MIRAI Software Package in the USB pendrive with the MIRAI Training App, and the user documentation.

READ FURTHER

Check out this link **for information on how to update MIRAI software.**

- ☐ Other supporting components: Ethernet switch, 1x L-mount for MIRAI, 1x Universal AC power supply (DC19V/120W), 1x AC power cord for EU and US region, 2x wireless antennas, 1x USB3 cable, 5x ethernet cables

Additionally, the following system components are recommended for a minimum MIRAI setup:

- ☐ Robot arm and its control system[3]
- ☐ Force/Torque (F/T) sensor

READ FURTHER

Check out this link **for the latest list of supported F/T sensors.**

Additional note: Using an F/T sensor is **optional for positioning skills**, but **mandatory for motion and multi-target positioning skills**.

1 For more details, see "MIRAI Components" in the User Manual for Universal Robots Integration, FANUC Integration, or KUKA Integration

2 Includes: 1x Ximea xiQ USB3 camera, 2x Fujinon lenses, 2x Camera fixtures for the robot arm, 4x M-6 mounting screws, 4x CBSTSR6-16 screws to mount the fixtures

3 Supported Robot models include:

- Universal Robots: UR3, UR5, UR10, UR5e, UR10e, UR16e (Minimum software versions required for UR e-Series: 5.3.0 (please do not use versions 5.5.x and 5.6.x), and for UR CB3 series: 3.9.0)
- Fanuc: CRX-10iA/L, M-20iB/25, LR Mate 200iD, LR Mate 200iD/4S, LR Mate 200iD/7L, R-2000iC/165F, R-2000iC/210F, R-2000iC/270F
- KUKA: MIRAI is compatible with all KUKA robot models that meet the following requirement: KR C4 or C5 controller, KUKA.Systems Software (KSS) 8.6 or 8.7.

MIRAI Skill Types

There are three types of MIRAI skills you can train with your setup:

01 Positioning Skills

Use for tasks that require accurate real-time positioning of a tool where the path is a straight, direct motion from the starting point to the final target position.

Applications include:

- Placing a gripper in a pre-grip pose over a variable object
- Positioning a work piece precisely for insertion
- Placing a sensor tool relative to a work piece for quality inspection

⚠ NOTE

For Positioning skills, it is possible to train with or without a Force/Torque sensor; however, both Multi-target and Motion skills require training with an F/T sensor.
This is discussed further in 'Creating a MIRAI Skill'.

02 Multi-target Positioning Skills (Beta)

Use for tasks that involve a robot moving in a straight, direct path towards multiple objects or positions.

Applications include:

- Picking objects from flat surface (3 or 4 degrees of freedom)
- Picking objects from a heap or bin (6 degrees of freedom)
- Handling objects with symmetries

This feature is currently released as a 'beta' version.

03 Motion Skills

Use for tasks with complex or dynamic motions, where the positioning of a tool is not sufficient, but you want to have full control over the robot's trajectory (the exact path, velocity, and acceleration).

Applications include:

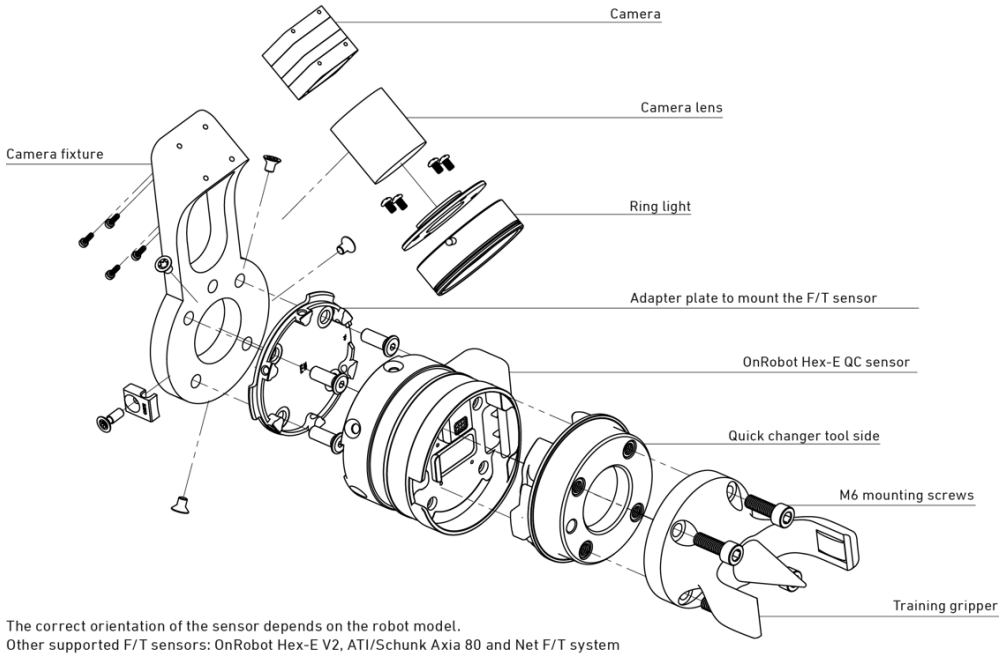
- Different types of insertion tasks (e.g., cable plugging)
- Path or contour following tasks (e.g., gluing)
- Picking or placing objects from and to a moving conveyor
- Quality inspection (e.g., positioning of sensors or cameras)
- Finishing tasks (e.g., polishing)
- Tool positioning where there are obstacles, and where the direct path from the starting point to the goal is not attainable

🎬 WATCH

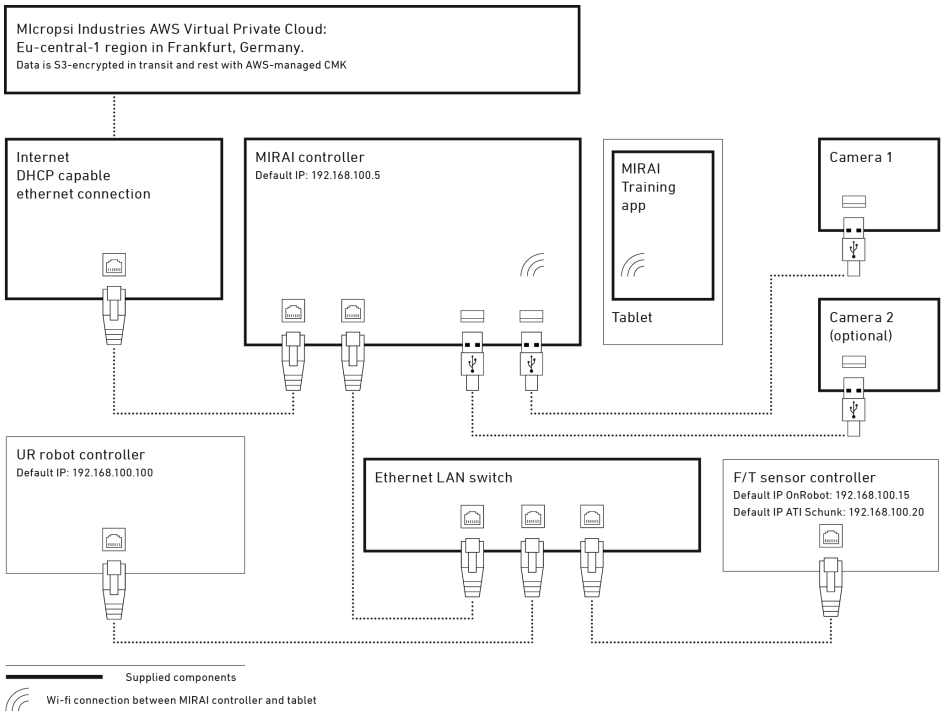
For more guidance on **how to choose the apt MIRAI skill for your application,** you can also check out this video:
Choosing a MIRAI Skill Type

Building Your Setup & Getting Started

Connecting the Devices



The correct orientation of the sensor depends on the robot model.
Other supported F/T sensors: OnRobot Hex-E V2, ATI/Schunk Axia 80 and Net F/T system



Before training with MIRAI, follow these steps to ensure your physical setup is ready:

01 Connect the MIRAI controller & Force/Torque (F/T) sensor[4]

- ☐ STEP 1
  Connect the MIRAI controller to the internet via an ethernet cable.

- ☐ STEP 2
  Connect the MIRAI controller to the robot via an ethernet cable.[5]
  - Ensure the connection to the MIRAI Controller is in the Robot LAN port.
  - If using an F/T sensor, connect the cable from the MIRAI controller to the ethernet switch, otherwise directly to the robot controller.

- ☐ STEP 3 (skip if using MIRAI without an F/T sensor)
  Connect the F/T sensor to the ethernet switch, and to an **external power supply** or the **power supply on the native robot controller.**
  - For Positioning skills, it is possible to train with or without a Force/Torque sensor; however, both Multi-target and Motion skills require training with an F/T sensor.

02 Assemble the cameras

- ☐ STEP 1
  Assemble the camera(s).
  - Attach the camera(s) to the lens(es) you prefer, then attach the ring light(s) to the lens(es).

- ☐ STEP 2
  Fasten the camera(s) on the camera fixture.

- ☐ STEP 3
  Connect the camera(s) to the MIRAI controller via a USB cable.

- ☐ STEP 4
  Connect the ring light(s) to power.

03 Start the MIRAI Training App[6]

- ☐ STEP 1
  Connect a 24V power supply to the MIRAI controller and turn it on.
  - Check the LED "RUN/STOP" for a green light to confirm successful system boot and started runtime.

- ☐ STEP 2
  Install the MIRAI Training App on your tablet (skip this if already installed).
  - Open the internet browser of the tablet and visit http://mirai:6543/mint/apk.
  - Click to confirm and download the MIRAI Training App installation file 'mint.apk'. After downloading, install the app.

4 For more details, see "Setting up the MIRAI Controller" in the User Manual for Universal Robots Integration, FANUC Integration, or KUKA Integration
5 For the UR e-Series, make sure the robot is put into *remote mode*.
6 For more details, see "Installing and Connecting MIRAI Training App" in the User Manual for Universal Robots Integration, FANUC Integration, or KUKA Integration

☐ STEP 3
Connect the tablet to the MIRAI controller via Wi-Fi
- Connect the wi-fi module to one of the USB slots for connection with the Android tablet.
- On the tablet's Wi-Fi settings, choose the network SSID from the MIRAI controller, which should be named 'MIRAI-####', and enter the password.

> ⚠ **IMPORTANT**
>
> **#### is the ID number** of the MIRAI controller.
> This, along with the **password,** are printed on your **controller's product card/sticker.**

☐ STEP 4
Open the MIRAI Training App
- If the cloud icon at the top-right corner appears with a green checkmark, this indicates your MIRAI controller has successfully connected to the Internet.
- If you are experiencing connection issues, open the Network Configurations in your MIRAI Training App, and configure your robot and the F/T sensor to match the IP settings of the MIRAI controller.[7]

04 Install the MIRAI Software Package on the robot

☐ *Universal Robots:* **Install the MIRAI URCap Plugin on the UR robot** via the USB provided.[8]

☐ *FANUC:* **Install the MIRAI software package on the FANUC robot** via the USB provided.[9]

☐ *KUKA:* **Install the MIRAI software package on the KUKA SmartPAD** via the USB provided.[10]

> 🎬 **WATCH**
>
> You can also check out the following videos for more guidance regarding:
>
> Cabling | Network Configuration | UR Caps E Series Setup

7 Robot: 192.168.100.100; OnRobot F/T Sensor:192.168.100.15; ATI sensor: 192.168.100.20.
8 For complete details, see "Installing the MIRAI URCap Plugin" in the MIRAI User Manual for UR Integration
9 For complete details, see "Setting up the FANUC Robot Controller" in the MIRAI User Manual for FANUC Integration
10 For complete details, see "Installing the Software Package on the KUKA SmartPAD" in the MIRAI User Manual for KUKA Integration

Composing Your Camera Setup

⚠ IMPORTANT

Camera setup is a critical step.
The position of the camera(s) and how the lens(es) are configured are both crucial in ensuring successful MIRAI training. There are 6 main parameters that affect your camera setup:

1. Camera position
2. Lens focal length choice and lens tube extension choice
3. Camera lens aperture setting
4. Camera lens focus
5. Camera image exposure
6. Camera signal gain

⚠ ATTENTION

Once you start training a skill, the camera setup cannot change for that skill. Multiple skills can use the same camera setup, but **modifying the camera setup would require creating a new skill.**

TIP

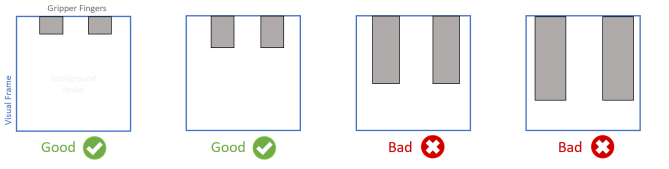
You can opt to design your camera setup in CAD. Contact your Micropsi Representative to request camera related CAD files (e.g., cameras, lens specific field-of-views (FOVs), Micropsi camera brackets). Designing your setup in CAD will help ensure a smooth and successful skill training; this will then reduce the likelihood of retooling your setup in the future.

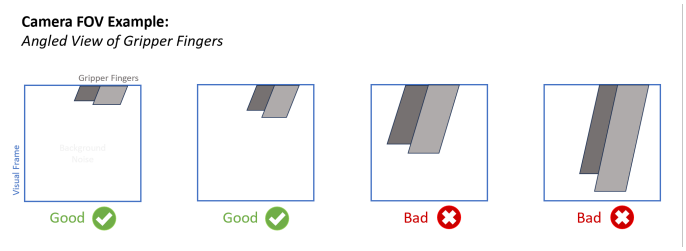
☐ STEP 1
Mount the camera(s) to the robot arm.

- When using Micropsi's universal camera mounts:
  - Select a bracket arm-length and mount it onto the robot in your first-choice location; additionally, consider the robot movements for your task and determine if there are any obstacles.
  - Attach the cameras to the swivel L-brackets; ensure the cameras are attached in the correct orientation (i.e., the writing on its back should be readable and not upside-down).

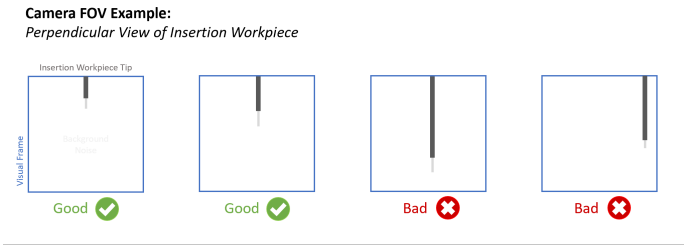
- When using custom camera mounts:
  - Design the camera mounts in CAD.
  - Ensure the object of alignment is in the camera's field of view (FOV).
    - Example: If the skill being trained requires grabbing an object, ensure the tool center point (TCP) is in the camera's FOV.

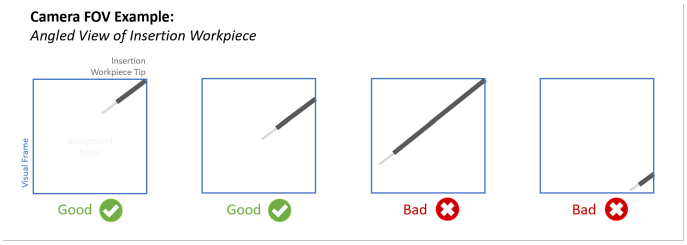
Camera FOV Example:
Perpendicular View of Gripper Fingers





- Example: If the skill being trained requires aligning an object for insertion, then ensure the part of the object that is to be inserted is in the camera's FOV.





TIP

Micropsi's universal camera mounts are good for the R&D and conceptualization stages of a project; however, **creating custom/application specific camera mounts should be considered for long-term and production level solutions.**

☐ STEP 2

Unplug the camera(s) from the MIRAI controller, and **plug the camera(s) into a laptop. Position, focus, and tune the camera(s)** for your application.

- Review the camera images using the Ximea CamTool[11]
- Place the robot's tool into the target position
- Adjust each camera's aperture and focus using the dials on the lens, and adjust their FOV by adjusting the camera / camera bracket / mounting arm positions

TIP

The camera's aperture (ranging from 1.4 to 16) controls the amount of light that the camera takes in — we recommend starting with the aperture dial set at 8, and then adjust from there.

☐ STEP 3

Plug the camera USB(s) back into the MIRAI controller.

- Tighten each setscrew on the camera lens to secure the position of both the aperture dial and the focus dial.

11 The Ximea CamTool software page can be accessed by visiting Ximea's Support page.

- Note each camera's configuration — this will be helpful in case of camera misalignment(s). This includes:
  - The camera(s)' bracket positions
  - The camera(s)' FOV / field of view(s)
  - What the camera(s) is focused on
  - The aperture number setting

☐ STEP 4
Restart the MIRAI controller to re-establish its connection with the camera(s).

WATCH

For more guidance on how to **effectively build your camera setup,** you can also check out the following videos:

Getting Your Camera Setup Right, Part 1

Getting Your Camera Setup Right, Part 2

Mounting the Camera, Sensor, End-Effector

Testing the Effectiveness of Your MIRAI Setup

ATTENTION

This step, along with the setup points discussed above, are **crucial in creating a successful skill.**
If the camera and tooling setup needs to be redone after skill creation, then the current skill version may become unusable.

To test the effectiveness of your MIRAI Setup, **guide the robot through its motion path and check the following:**

☐ CONSIDERATION NO. 1
Along the motion path, **are there any obstacles that may lead to a potential collision between the robot tooling + camera setup and the environment? If YES, then:**
- Re-mount the cameras so that the robot tooling is clear of any obstacle, then revisit "Composing Your Camera Setup".
- Reconfigure the fixturing so that the obstacle is cleared from the robot's motion path.

☐ CONSIDERATION NO. 2
Be mindful of the **robot's limitations. Can the robot reach the target and travel along its ideal motion path?**
- Extra reach should be accounted for when considering how MIRAI will control the robot movement.
- If robot reach is at or near its limit:
  - Position to the robot and fixturing nearer to each other or in an orientation that enables greater robot freedom.
  - Revisit "Composing Your Camera Setup".
- Check for the potential of robot singularity in the areas where you expect to train MIRAI.

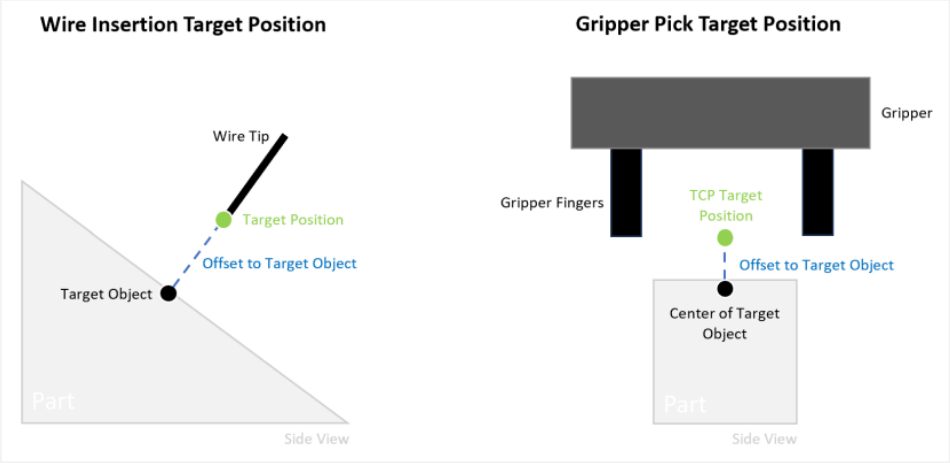
Quantifying Your Target Position

(only applicable to Positioning and Multi-target Positioning skills)

☐ STEP 1

Move the robot tool into the target position

- The target position you set for MIRAI should not be directly on the part — it should be offset from the part in such a way that the robot will have a clear path to the target object.
  - Example: If inserting a wire into a hole, the target position should offset the wire tip several millimeters perpendicular to the plane of the hole.
  - Example: If grabbing a part, the target position should place the gripper fingers at an offset of several millimeters above the part



☐ STEP 2

Quantify and record the Robot Tool's target position in relation to the part.

- Measure the distances and angles between the Robot tool and the part.
- Take note of the movements that brought the Robot into this particular position.

⚠ IMPORTANT

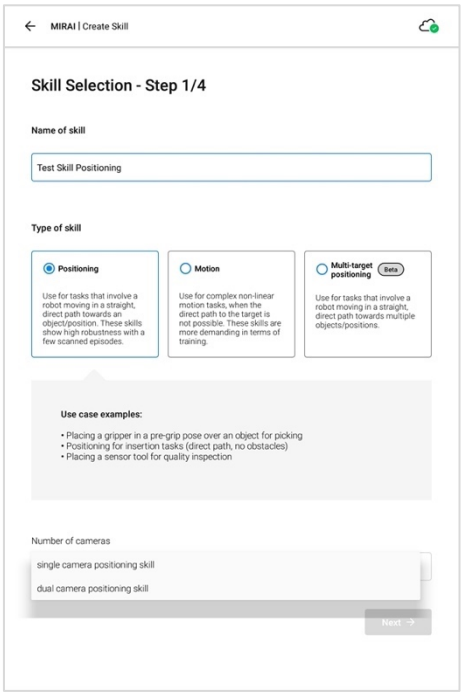
This step **ensures you can recreate your ideal tool positioning above the target for future episode training sessions. This is key in being able to obtain good training data.**

- Consistent tool positioning above the target would result in consistent start frames = **good training data**
- Inconsistent positioning above the target = **bad training data** (this could corrupt a skill that is already working well; nonetheless, these could be removed via data review, which will be discussed in 'Refining MIRAI Skills').

Creating a MIRAI Skill

In the MIRAI Training App, select **'Skill Overview'** on the main menu, and tap **'Add new skill'**[12].

☐ STEP 1
Enter a meaningful skill name, select the skill type depending on your use case **(choose 'Positioning' if you are not using an F/T sensor;** this is discussed further in STEP 2*), followed by the **number of cameras you will use** for your setup.



⚠ IMPORTANT

Currently, **skill names are not editable,** so it is recommended to enter a distinct and descriptive skill name.

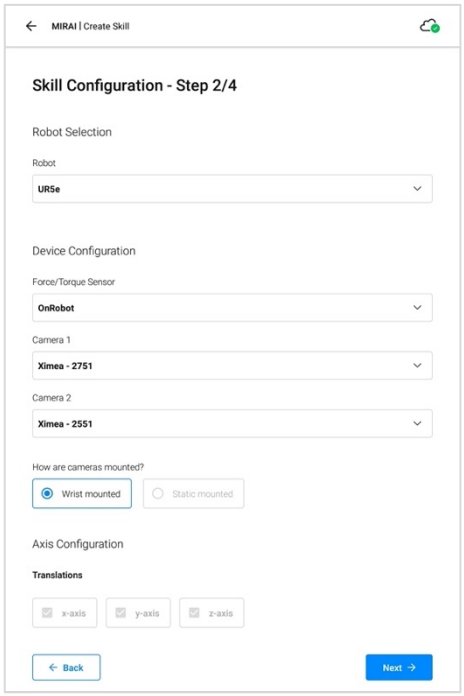
In case connection errors occur at this step:

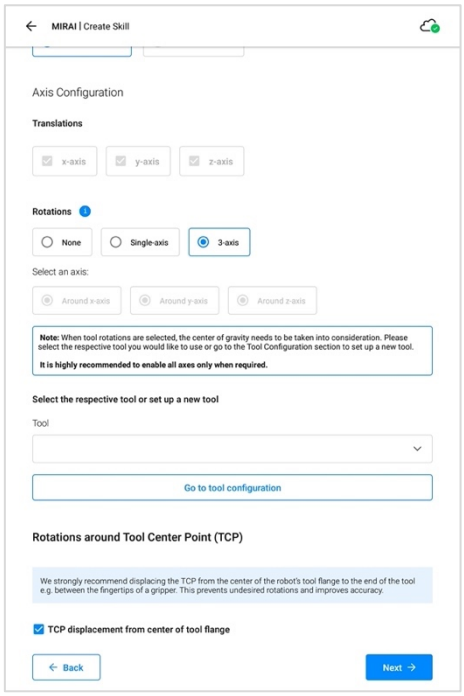
- Check the cable connections between devices.
- Check the power of all devices.
- Check the internet connection.
- Check if the robot is in 'Local' mode (a timeout error will be triggered in this case; set the robot to 'Remote' mode).
- Check IP address or network configurations in the MIRAI App.
- Review 'Connecting the Devices'.

12 For more details, see "Creating a New Skill" in the MIRAI User Manual for MIRAI Training

☐ STEP 2

Follow the app as it guides you through selecting the appropriate settings for your setup: **robot model, F/T sensor*, cameras, camera mount**, axis configuration (translations and rotations)***, the tool (if applicable^),** and TCP displacement^^.





⚠ IMPORTANT

- * If you choose to train without an F/T sensor:
  - Note that **hand-guiding is deactivated, and you can only train using Positioning skills and with the Recording Assistant.**
  - Relatedly, you must choose **'Positioning' as the skill type.** While other types can technically be chosen, it would not be appropriate to do so when training without a sensor.
  - Select **'None' from the 'Force/Torque Sensor' dropdown** menu.

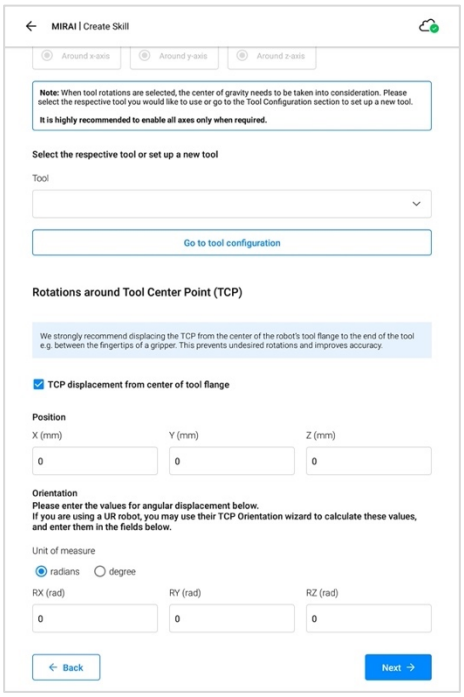
- ** Select the 'static-mounted' option only if your camera is not mounted on the robot wrist, but is placed independently on the working space (currently only applicable for motion skills.)

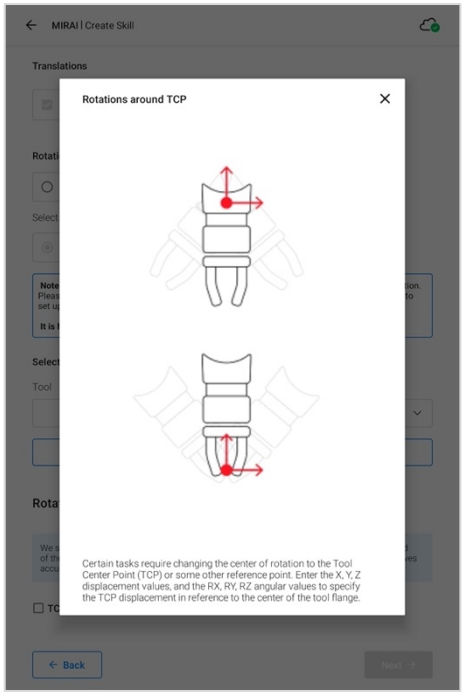
- *** It is **highly recommended to enable all axes when it is really required,** to limit the degrees of freedom and ensure the trained trajectory is stable.
  - **Translational axes:** You can train robot movements across all three axes; de-selecting one or more is only recommended when a robot's movement needs to be restricted.
  - **Rotational axes:** You can enable all three rotational axes for positioning and multi-target positioning skills, but only one axis can be enabled for motion skills.

- ^ **When using an F/T sensor and rotations are enabled, you must specify a respective tool** or tap 'Go to tool configuration' to **set up a new tool.**[13]

- ^^ It is **strongly recommended to displace the TCP from the center of the robot's tool flange to the end of the tool** (e.g., between the fingertips of a gripper). This prevents undesired rotations and improves accuracy. To do this, **check the 'TCP displacement from center of tool flange' box option.**

13 For more details, see "Tool Configuration" in the MIRAI User Manual for MIRAI Training or visit our Support Center.





WATCH

For more guidance on **configuring your tool on MIRAI**, you can also check out this video: [Tool Configuration for MIRAI]

TIPS

Having your TCP values set correctly makes training easier; however, it does not seriously affect the skill's performance if some values are slightly imprecise.

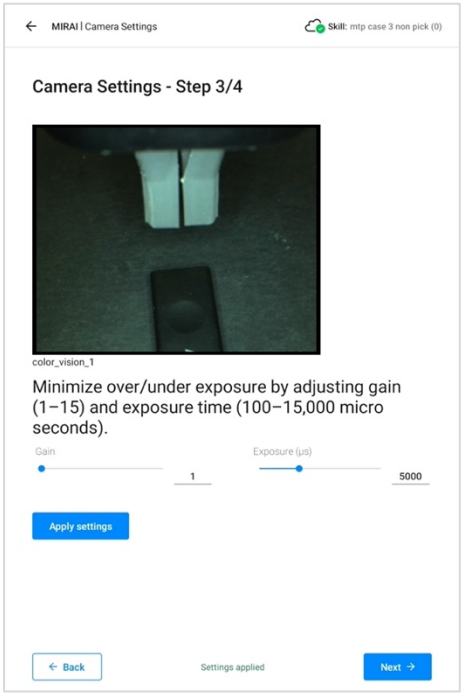
Here are some methods you can follow to determine your values:

- Working with UR: The robot has a TCP wizard to help you find these values
- Working with CAD: If you have already modeled the tool's end there, you can also find these values
- You can also measure with a ruler or measuring tape

When entering TCP values, remember that the coordinates are relative to the robot's tool flange.

☐ STEP 3

Turn on the ring light(s) of the camera(s) and use the live video feed to verify that **all the parts which play important roles in your task,** such as the robot end effector **and the target object(s), are visible.**



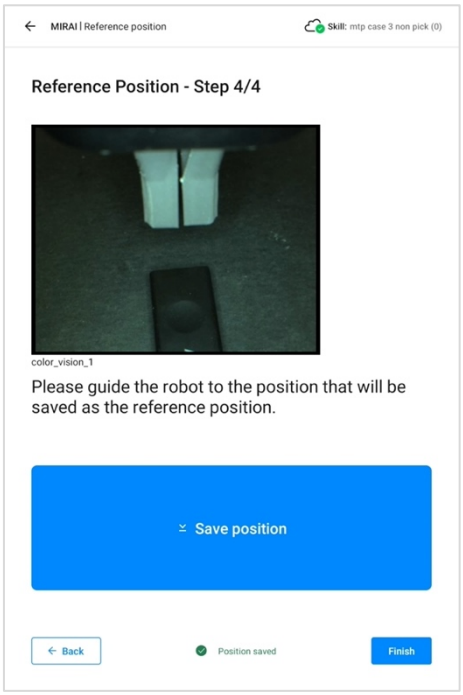
⚠ NOTE

The most crucial part in this step is that the **visual information of the target(s) and the element(s) which indicate the target(s)'s position should be bright enough to be recognized under a variety of lighting conditions.** In other words, the **background or other features which are not important do not need to be recognizable;** in fact, this will result in less noise for training models.

That said, **minimizing the gain value would be recommended.**

☐ STEP 4

Set a safe reference position **for the TCP by guiding the robot to the desired position** (ideally, several inches away from the target position). Tap 'Save Position' and 'Finish' after.



TIP

The skill's reference photos are also set during this step — these help identify the skill in the future and can be viewed in the skill's 'Details' screen.

You can place a white sheet of paper in front of the cameras to create a nice background for the reference photos; this can help distinguish the tool tip from the background whenever camera realignment is necessary.

Training a MIRAI Skill

Preparing to Train with MIRAI

Episodes

This section will heavily involve recording 'Episodes': video recordings which MIRAI's machine learning model utilizes as training data to create skills.

Before Recording Episodes: Check Your Robot Settings

(applicable to all skill types)

☐ STEP 1

On your robot's teach pendant, **set the robot speed override.**

TIP

- **Lower speed override (30-70%):** Use this setting when you want to ensure precise movements, precise positioning skills, and/or when working with high-zoom lenses.
- **Higher speed override (70-100%):** Use this setting when the movements and/or positioning is not so precise, and/or when working with low-zoom lenses.

☐ STEP 2

- *Universal Robots:* Change the robot's mode from 'Local' mode to 'Remote' mode. This setting enables episode recording with MIRAI.
- *FANUC:* To ensure safety MIRAI can only function on FANUC robots that operate in T1 mode.[14]
- *KUKA:* You will need to press both the enabling switch and the start key.[15]

Before Recording Episodes with MIRAI

(applicable to all skill types)

Please read through the different scenarios below to understand which key steps you must follow before and when recording episodes with MIRAI (as steps would differ depending on the skill type you are training).

- *When training Positioning skills with an F/T sensor, follow all the steps described below, then proceed to either 'Recording & Saving Episodes: Manual' if you are manually hand-guiding the robot, OR to 'Recording Episodes using the Recording Assistant (Beta)' if you are using the recording assistant (both these sections can be found within 'Training Positioning Skills'.*
- *When training a Positioning skill without an F/T sensor, follow steps 1 and 2 below, then proceed to straight to 'Recording Episodes using the Recording Assistant (Beta)' within the 'Training Positioning Skills'.*
- *Otherwise, follow all the steps described below, then proceed to either 'Training Multi-target Positioning (Beta) Skills' to train a Multi-target Positioning skill, OR to 'Training Motion Skills' to train a Motion skill.*

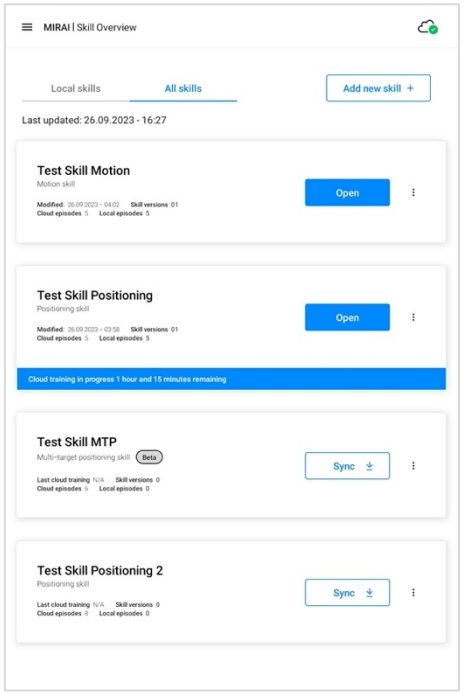
14 For complete details, see "Getting Started" in the MIRAI User Manual for FANUC Integration
15 For complete details, see "Using the MIRAI Training App with KUKA smartPAD" in the MIRAI User Manual for KUKA Integration

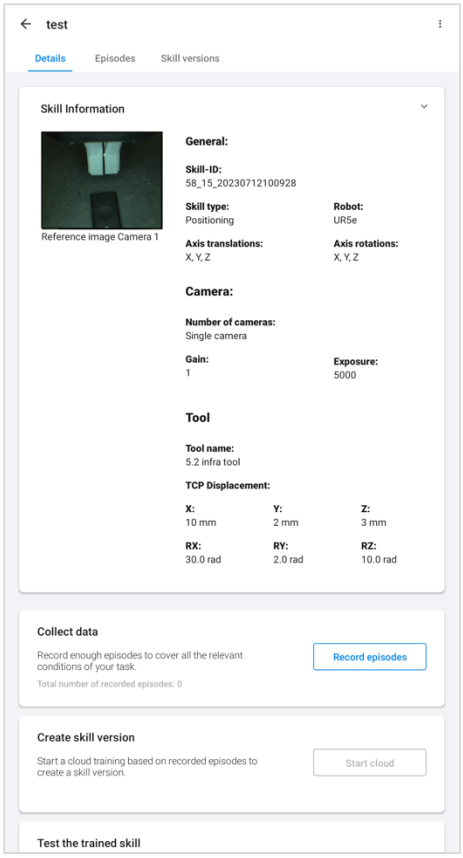
☐ STEP 1

After skill creation, head to the **home screen** and tap **'Open' on the right-hand side of your newly created skill;** this will lead you to the 'Details' screen which contains information about your skill, and the rest of the steps involved in the training and testing process.

☐ STEP 2

In the **'Details'** screen, select the **'Record episodes'** button to start.





☐ STEP 3

For Positioning or Multi-Target Positioning skills:

Guide or jog the robot in such a way that the tool is placed **precisely at the correct** target position **where the robot should *stop* the MIRAI execution and perform the next task** (e.g., insertion, picking, testing).

For Motion skills:

Guide the robot to a start position within the working space from which the MIRAI skill might *start* executing.

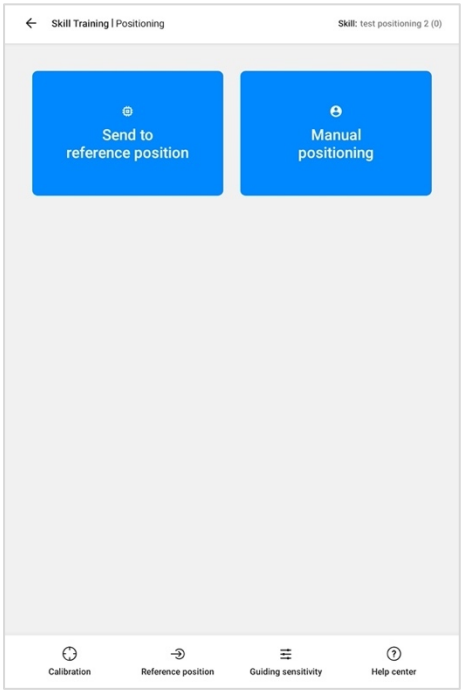
If using an F/T sensor, you'll have the option to select either **'Send to reference position'** (sending the robot to the predefined reference position when the skill was created) or **'Manual positioning'** (guiding the robot to the desired position manually). If you don't use an F/T sensor, you can find **Send to reference position'** in the bottom bar.

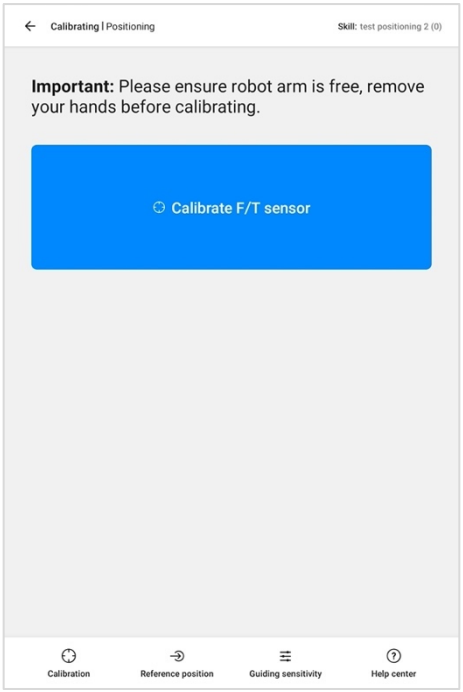
TIP

- **For positioning skills, you can use 'Send to reference position'** to get the tool close to the target, and then guide or jog the tool into the precise target position.

☐ STEP 4

Remove hands from robot to calibrate the F/T sensor, then **tap 'Calibrate F/T sensor'** to proceed. (Skip this step if you are not using an F/T sensor.)





☐ STEP 5

Adjust the guiding sensitivity by tapping 'Guiding Sensitivity' button in the bottom bar.[16] ***(Skip this step if you are not using an F/T sensor.)***

TIP

- **High sensitivity:** Quicker robot response time; easier to move the robot
- **Low sensitivity:** Slower robot response time, harder to move the robot

☐ OPTIONAL STEP

You can also utilize 'Tags' on your episode (or series of episodes) with meaningful text labels which describe the condition, environment, or the object associated with the episode. This could help you plan and keep track of your recording steps.[17]

☐ ADDITIONAL REMINDERS FOR POSITIONING SKILLS

(check your setup one more time before every episode recording!):

- Make sure that **there is no obstruction** for the direct path from the starting position (handover point) to the target position.
- Make sure to **remove other objects that are in the view** and could disturb the training of a skill (e.g., the tablet, appendages).
- Make sure that **at least part of the target must remain visible** in at least one (1) of the two (2) possible camera feeds during the whole episode recording.

16 For more details, see "Guiding Sensitivity" in the MIRAI User Manual for MIRAI Training or visit our Support Center.
17 For more details, see "Adding Tags or Text Labels for Episodes" in the MIRAI User Manual for MIRAI Training or visit our Support Center.

Training Positioning Skills

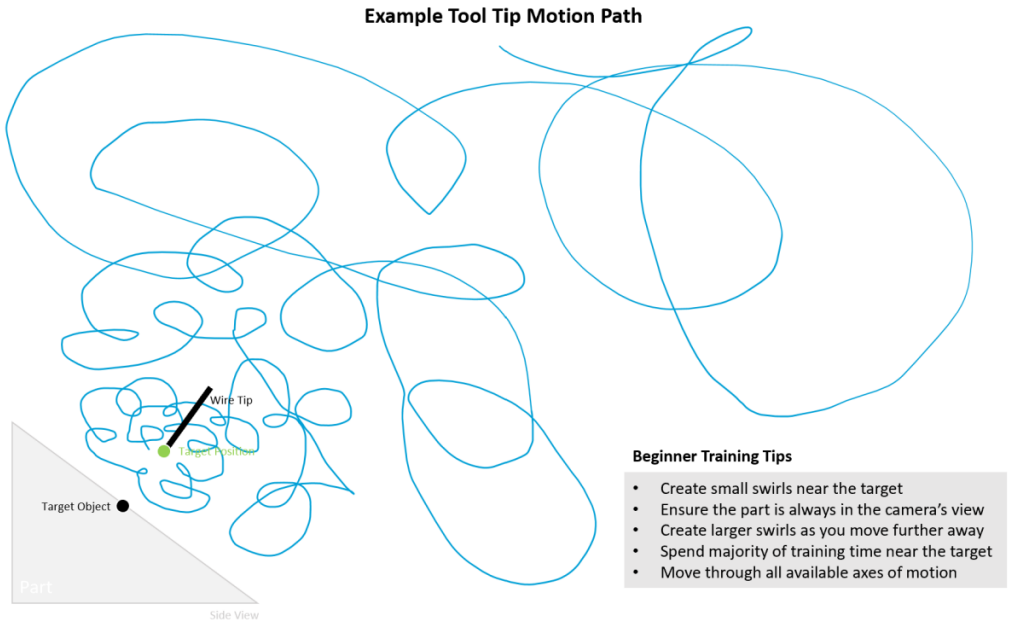
Before training, kindly ensure you have read through the instructions above ('Overview of Training with MIRAI'), and those within this section ('Recording & Saving Episodes: Manual)', 'Recording & Saving Episodes using the Recording Assistant (Beta)', 'Best Practices When Recording Positioning Skills').

Recording & Saving Episodes: Manual

☐ STEP 1
Now that you have ensured that the robot's TCP is in the final target position, tap the **'Start recording'** button.

> **⚠ IMPORTANT**
>
> When recording your episode, **the start frame that appears on the screen should be consistent with the target start frame from when you created the episode;** subsequently, this should also be **consistent across all episode recordings.**
>
> The **camera grid feature**  (found at the top right corner of the camera view) can help with positioning the robot more accurately or easily.

☐ STEP 2
Begin moving the robot in swirls around the target and take it through all the relevant points, perspectives, and orientations it may encounter during skill execution.



☐ STEP 3
Tap **'Stop Recording' once the task is done.**

☐ STEP 4
If the **episode recorded is optimal, 'Save' it; if not, 'Discard' it.**

💡 TIP

It would be best to discard the episode recording if:
- Your hand was in front of the camera feed.
- The target object was accidentally moved during recording.
- The lighting condition was suboptimal or changed suddenly during the recording (e.g., the ring light was turned off).
- The gripper or the target object was not part of the camera feed.

The number of successfully recorded episodes is indicated on the top-right corner.

☐ STEP 5
After every episode recording, you need to **calibrate F/T sensor** again to avoid drifting during guiding.

☐ STEP 6
You can then **'Start recording' another episode** (following the same steps detailed above for every recording).

☐ STEP 7
Once you have **recorded and saved 5 to 10 optimal episodes,** head back to the 'Details' screen of the skill and select **'Start cloud training'.** More details about this will be discussed in the section 'Cloud Training'.

Recording Episodes using the Recording Assistant (Beta)

The Recording Assistant enables you to **train robust positioning skills through automated recording wherein the robot is autonomously moved within a predetermined area.** This feature **can only be used for training positioning skills** (new, old, with or without rotations), and **can be used whether you are or are not utilizing an F/T sensor in your MIRAI setup**. It cannot be used when training multi-target positioning or motion skills.

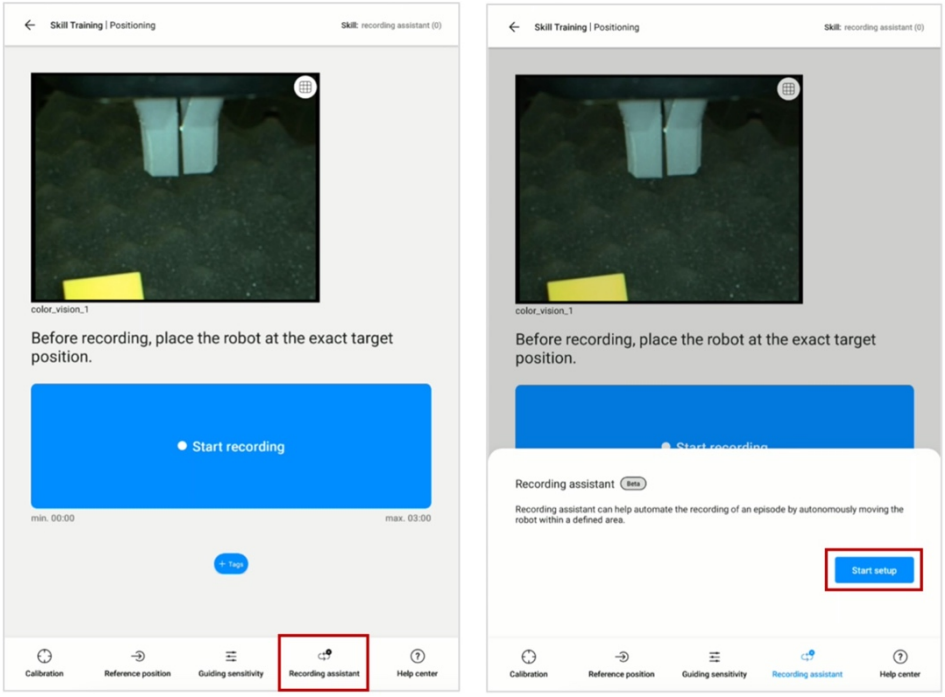
⚠ IMPORTANT

The Recording Assistant needs **±5mm of free moving space and ±5° of free turning space around the target TCP pose in all enabled axes.**

Prior to using the Recording Assistant feature, it is important to:
- Predetermine where your **desired handover region is.** Without this, you will not be able to use the feature later.
- Enter the tool center point (TCP) displacement while creating the skill.

☐ STEP 1
To use this feature, select **'Recording assistant '** at the bottom right corner.

☐ STEP 2
Set up the Recording Assistant feature by tapping 'Start setup'.



The setup will involve two major sub-steps, detailed in STEP 2.1 and STEP 2.2.

- STEP 2.1
  Choose the handover behavior by selecting one of the following:
  - 'Handover point stays fixed (default)': If every execution of the skill being trained starts roughly from the same position in the workspace.
  - 'Handover point moves with target': If the skill will be executed at different positions in the workspace, depending on the position of the intended target object.

> **TIP**
>
> **When choosing the handover behavior, consider your application workspace:** Where will the robot tool be when the MIRAI skill takes control? Does this stay fixed from execution to execution?
>
> **For most applications, the handover point will stay the same for every execution** (default setting). However, for certain tasks such as depalletizing, it can be useful to start each skill execution at a new location that depends on the position of the intended target.

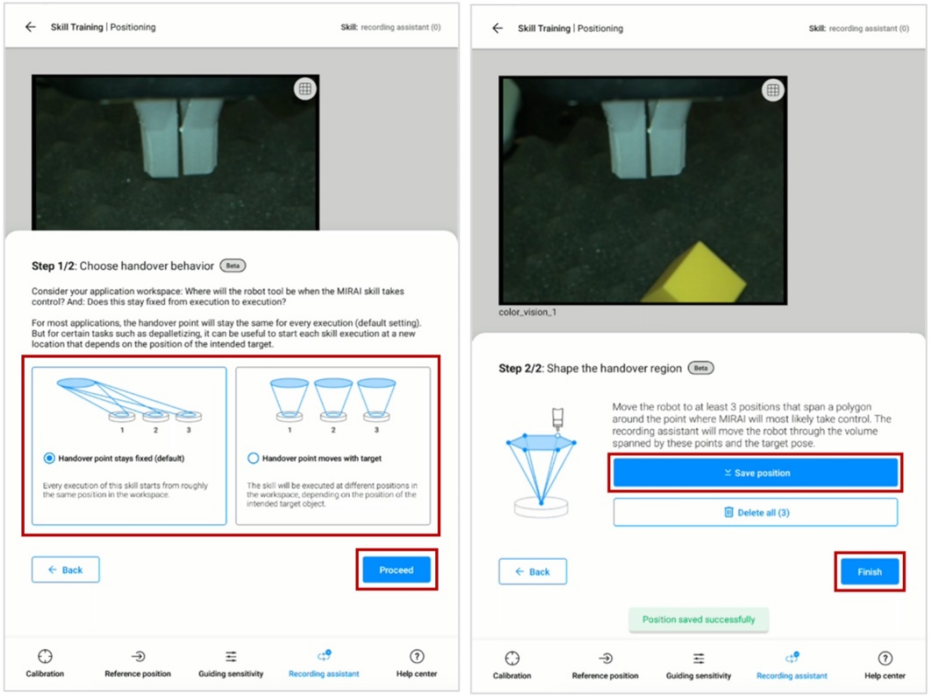
  Then tap 'Proceed'.

- STEP 2.2
  Shape the handover region:
  - Move the robot to at least 3 positions that span a polygon around the point where MIRAI will most likely take control. The Recording Assistant will move the robot through the volume spanned by these and the target pose.
  - Click 'Save position' after every position you determined.
  - Once you are satisfied with your selection, click 'Finish'.

TIP

When deleting handover positions:

- Below the 'Save position' button, the 'Delete all' button will indicate how many handover positions you have saved so far.
- If you are not satisfied with what you have saved, you may 'Delete all' and start over.
- When the handover points you have determined do not span a polygon, you will need to delete all the positions and start over.



Once you are done with the two sub-steps above, the Recording Assistant setup is ready to use. You can choose to move on with recording an episode or modify your setup if needed.

⚠ SAFETY REMINDERS

Please note the following safety reminders before proceeding with the Recording Assistant:

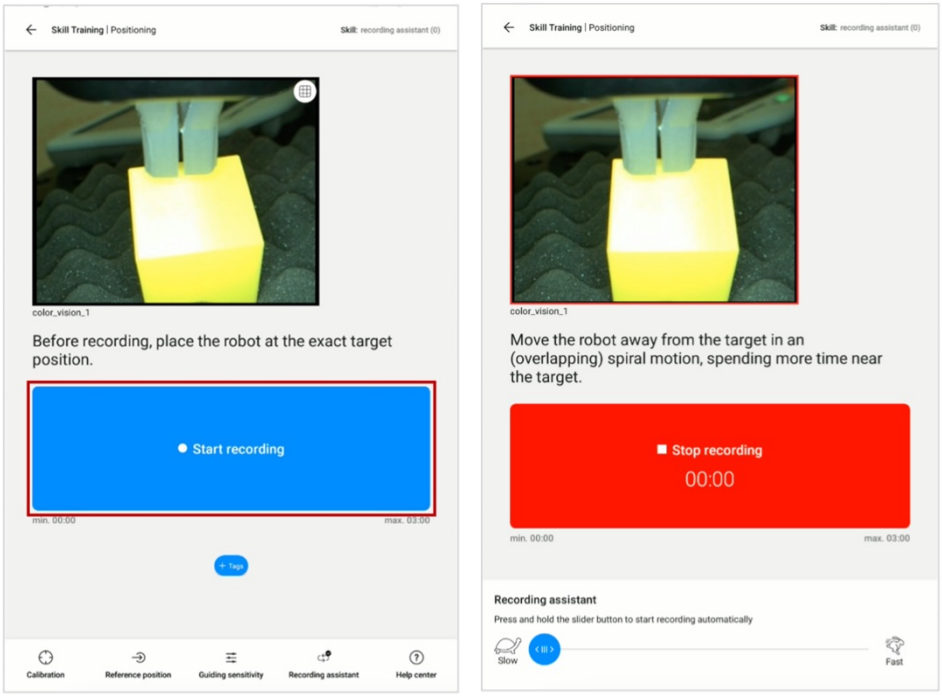
- Keep a close watch on the robot's motion. Interrupt the process if necessary.
- Pay special attention to good cable management when training. The robot may rotate a lot while the feature is used.
- Especially if the TCP was not displaced (when using an F/T sensor), use the feature cautiously and slowly, and observe if the robot's motion aligns with your preference.

☐ STEP 3

Now that you have finished your setup, **place the robot at a desired target position** when you are ready to record, then **tap 'Start recording'** to proceed.

☐ STEP 4

Press and hold the slider button (at the bottom of the screen) to start the recording automatically, as well as set the speed— this will allow you to determine or adjust **how slow or fast the scanning motion should be**. The recording assistant will not begin until you have selected your speed preference. Additionally, if you let go of the slider while recording, the robot will stop.



TIP

When choosing your speed preference and proceeding with recording:

- We recommend that you start with the slowest (default) setting (i.e., the turtle icon on the leftmost side; alternatively, the rabbit icon on the rightmost side represents the fastest setting).
- If the robot is too far away from the defined handover region, move the robot to the appropriate area and restart the recording.

☐ STEP 5

You are **notified when the Recording Assistant has finished;** however, the **recording of the episode will not be automatically terminated.** You must select **'Stop recording'.**

☐ STEP 6

If the **episode recorded is optimal, 'Save' it; if not, 'Discard' it.**

TIP

It would be best to discard the episode recording if:

- Your hand was in front of the camera feed.
- The target object was accidentally moved during recording.
- The lighting condition was suboptimal or changed suddenly during the recording (e.g., the ring light was turned off).
- The gripper or the target object was not part of the camera feed.

The number of successfully recorded episodes is indicated on the top-right corner.

☐ STEP 7

Choose a different target position, then tap **'Start recording' to proceed with the next episode** (follow STEPS 4 to 6 as detailed above for every recording).

☐ STEP 8

Once you have **recorded and saved 5 to 10 optimal episodes,** head back to the 'Details' screen of the skill and select **'Start cloud training'.** More details about this will be discussed in the section 'Cloud Training'.

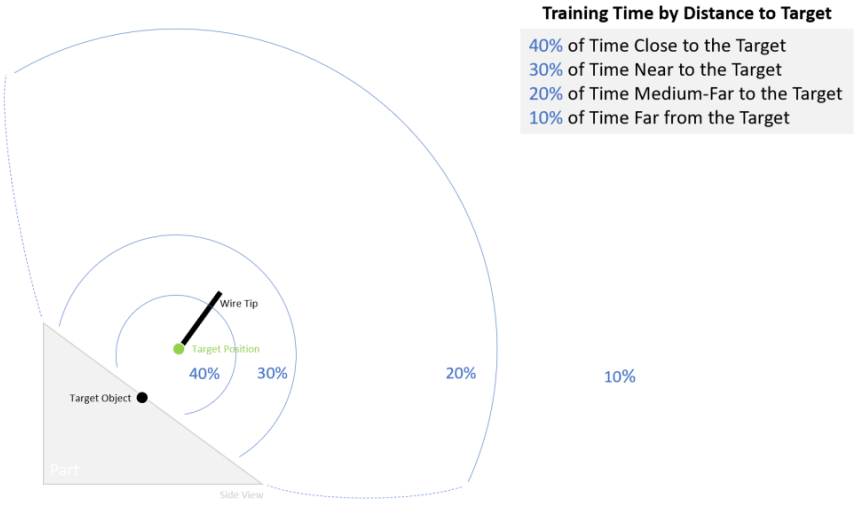
Best Practices When Recording Positioning Skills

- DO: Ensure start frames are consistent.

  The robot tool needs to be precisely positioned at the target before every episode. Remember:
  - Consistent start frames = good training data
  - Inconsistent start frames = bad training data, and will corrupt the skill

- DO: When hand-guiding the robot, use the 40-30-20-10% Zone Rule.

  Allocate episode training time based on the distance of the tool to the target object. This is highly recommended especially when recording your first ≈20 episodes, but becomes less important from thereon.
  - Example: Spend 40% of your recording time close to the object (up to 5 mm), 30% near the object (5 mm to 10 mm), 20% within medium distance from the object (10 mm to 50 mm), and lastly, 10% far away from the object (greater than 50 mm).



- DO: Show MIRAI every possible perspective.

  This allows MIRAI to learn to go to the target from all the different perspectives you show it during training. Conversely, perspectives you do not show MIRAI will become "blind spots", and MIRAI will have trouble when mapping to the target from these positions.

- DO: Move through all available axes of translation and rotation (if enabled) while recording episodes.

  This teaches MIRAI how to utilize all axes of movement while approaching the target.
  - Example: If it is a 6-axis skill, it would be best to move the robot tool through all 6 axes of motion; if it is a 4-axis skill, it would be best to move the robot through the 3 axes of translation, while also rotating the 4th axis.

- DO: When recording manually, 'rubber-band' (i.e., occasionally let go of) the robot about 2 to 3 times per episode.

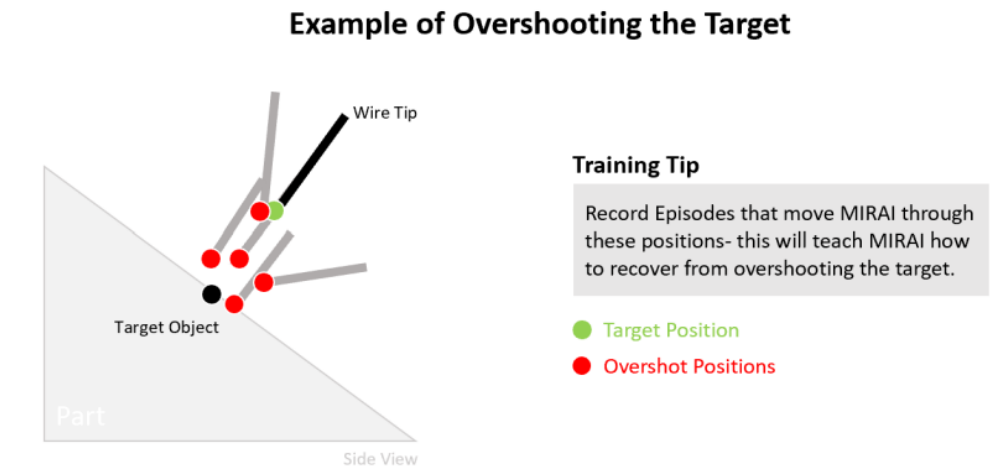
  This shows MIRAI direct paths to the target, and it will help you show MIRAI more variance around the target per episode.

- DO: **Every time you record an episode, expose MIRAI to various relevant variances. This will result in a more robust skill during execution**.
  - MIRAI does not learn from being shown the same thing twice or more times.
  - **Variations often relevant in automation tasks can include:**
    - Varying starting and ending points of trajectories
    - Varying the position of target objects in a task or during the manipulation of the working part.
    - Changing background or moving objects in the background (this is only relevant if the background is visible in the recorded episodes).
    - Differences in the color and/or shapes of the objects/working parts.
    - Changes in lighting conditions (e.g., changing intensity of daylight)
    - Imprecisions and variations in gripping positions at the TCP.

- DO: **Record shorter episodes (20 seconds) if your target object varies a lot.**

> **TIP**
>
> For example, if you are working on many target objects (e.g., 50), having a 20-second episode recording for each object (i.e., 50 x 20-second recordings) is better than 1-minute recording for a smaller number of objects (e.g., 5 or 10).
>
> In other words, **show MIRAI all the possible variations as much as you can — as efficiently as possible.**

- DO: **Include recovery episodes — teach MIRAI how to recover by showing what it looks like to overshoot the target or go to states it should never reach.**
  This will ensure it knows how to get back on track, i.e., move towards the target position, when it makes a mistake or finds itself in undesirable states.



- DO: **Train 5 to 10 good episodes (with relevant variance) at first,** then head back to the 'Details' screen and select **'Start cloud training' to get your first skill version.**[18]
  It is recommended to not record too many episodes before sending them to the cloud for training. See 'Cloud Training' for more details.

WORD OF ADVICE

Experience shows that the **first few recordings could be difficult** for users who are new to the system. **Once you find your routine and what works for you, the process becomes much easier!**

- DO: **Create backups of the data on your MIRAI Controller.**
  It is good practice to occasionally create backups — especially once you have developed your skill to a satisfactory level. This will be very helpful if your Controller gets damaged or destroyed.

READ FURTHER

Check out this link for information on how to create a backup of your MIRAI skills.

- DO NOT: **Move the target or introduce any variance during recording.**

- DO NOT: **Move the robot tool into areas or orientations it should never go to.**
  Showing MIRAI irrelevant areas is inefficient and will not help make the skill more robust.

- DO NOT: **Collide with the target.**
  Doing so will likely displace the target and the tool and will result into creating bad training data (which would corrupt the skill). It is recommended to delete any episode which shows the tool colliding with the target or fixture.

WATCH

For more guidance on **training positioning skills,** you can also check out this video:
How to Train a MIRAI Positioning Skill

18 For more details, see "MIRAI Cloud Training and Skill Versions" in the MIRAI User Manual for MIRAI Training or visit our Support Center.

Training Multi-Target Positioning Skills (Beta)

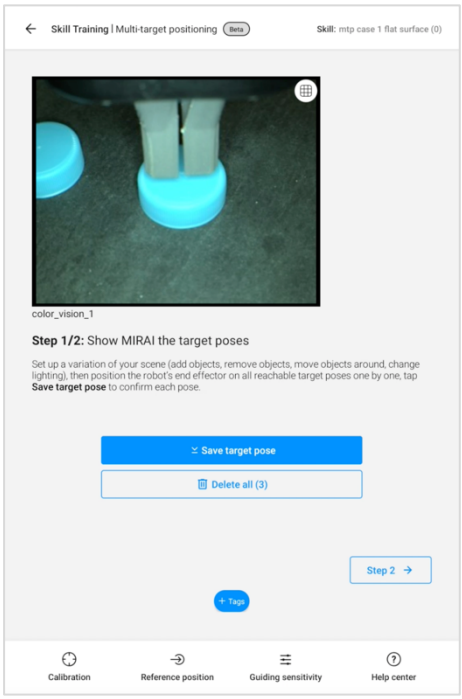
Before training, kindly ensure you have read through the instructions in 'Overview of Training with MIRAI', and those within this section ('Before Recording Episodes for Multi-target Positioning Skills', 'Recording Major Step 01: Show MIRAI each of the desired target poses', 'Recording Major Step 02: Show MIRAI the scene', and 'Best Practices When Recording Multi-target Positioning Skills').

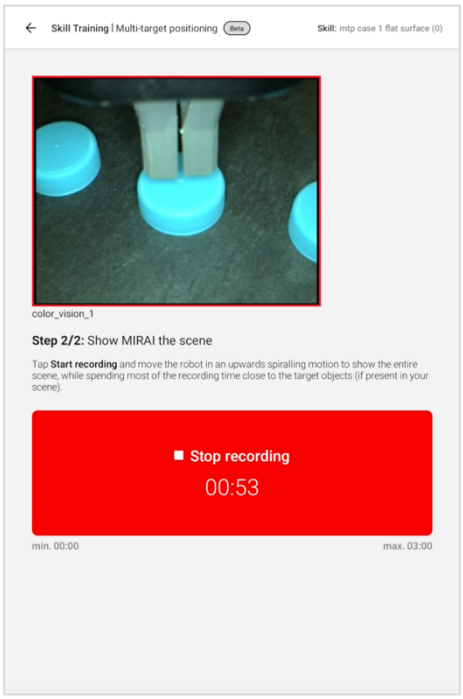
Before Recording Episodes for Multi-Target Positioning Skills

⚠ ATTENTION

It is strongly recommended to displace the tool center point (TCP) to the tool tip.
Otherwise, MIRAI may misjudge the distances to the target object(s) and not pick the closest object.[19]

Recording an episode for multi-target positioning skills involves two major steps:





Recording Major Step 01: Show MIRAI each of the desired target poses

☐ STEP 1.1
Position the robot's end effector on the first reachable target, then select **'Save target pose' to confirm the pose.**

☐ (REPEATING) STEP 1.2
Move on to the next reachable target, then select **'Save target pose' once again.**
Repeat this process as necessary.

19 For more details, see "Tool Configuration" in the MIRAI User Manual for MIRAI Training or visit our Support Center.

⚠ IMPORTANT

The **target poses should be as precise as possible and consistent** across episodes.

The **camera grid feature**  (found at the top right corner of the camera view) can help with positioning the robot more accurately or easily.

TIP

- Below the 'Save target pose' button, the 'Delete all' button will indicate how many target poses you have saved so far.
- If you are not satisfied with the target positions you have saved, you may choose to 'Delete all' and start over.

☐ STEP 1.3
Once you are content with your saved target poses, tap '**Step 2**' at the bottom right corner of the screen.

Recording Major Step 02: Show MIRAI the scene

☐ STEP 2.1
To start **showing MIRAI the working environment,** tap **'Start recording'.**

☐ STEP 2.2
Move the robot in an upwards spiralling motion to show the entire scene, while **spending most of the recording time close to the target objects** (similar to the motion described in Step 2 under 'Training Positioning Skills - Recording & Saving Episodes: Manual'). Your recording can last up to 3 minutes maximum.

☐ STEP 2.3
Once you are done, tap **'Stop Recording'.**

☐ STEP 2.4
If the **episode recorded is optimal, 'Save' it; if not, 'Discard' it.**

TIP

It would be best to discard the episode recording if:
- Your hand was in front of the camera feed.
- One of the target objects was accidentally moved during recording.
- The lighting condition was suboptimal or changed suddenly during the recording (e.g., the ring light was turned off).
- The gripper or none of the target objects was visible at any moment during the camera feed.

The number of successfully recorded episodes is indicated on the top-right corner.

☐ STEP 2.5
After every episode recording, you need to **calibrate F/T sensor** again to avoid drifting during guiding.

☐ STEP 2.6
You can then **'Start recording' another episode** (following the same steps detailed above for every recording). Once you have **recorded and saved 5 to 10 optimal episodes,** head back to the 'Details' screen of the skill and select **'Start cloud training'.** More details about this will be discussed in the section 'Cloud Training'

Best Practices When Recording Multi-Target Positioning Skills

When recording your episodes, it is recommended to **show the following variance in your scene:**

☐ RECOMMENDATION NO. 1
Record scenes with relevant objects (majority of your episodes).
- Start with many pickable objects in the scene. In subsequent episodes, vary and lessen the number of objects.
- Move objects around between episodes.
- Make use of various lighting settings.

☐ RECOMMENDATION NO. 2
Record some cases where only non-relevant objects are present.
- These should include variance such as: "upside down" / "wrong side up" / non-pickable objects.
- At least one recording should show an empty scene — i.e., a scene with no objects present at all / zero objects present.

TIP

When you show MIRAI scene(s) with non-relevant objects:
- You can teach the robot where it must go by **saving a target pose above that scene,** so it knows where to return to and wait for a change in the scene (i.e., MIRAI will help the robot realize that there is nothing to pick in this case**). It is important to be consistent in this target pose.** You can use the 'Reference Position' feature to help you with this.
- For stopping conditions, ensure there is a **fixed visual cue or a landmark in the scene that enables MIRAI to identify when to stop** (Note: You can also use the position-based end state for this).

Training Motion Skills

Before training, kindly ensure you have read through the instructions in 'Overview of Training with MIRAI', and those within this section ('Recording & Saving Episodes' and 'Best Practices When Recording Motion Skills').

Recording & Saving Episodes

☐ STEP 1
Place the robot in the **starting position,** tap the **'Start recording'** button.

> ⚠ **IMPORTANT**
>
> The **camera grid feature**  (found at the top right corner of the camera view) can help with positioning the robot more accurately or easily.

☐ STEP 2
Guide the robot in a smooth motion to the target position. This can be a curved trajectory to move around obstacles, but it **should be the shortest, most direct path.**

☐ STEP 3
Tap 'Stop Recording' once the task is done.

> ⚠ **IMPORTANT**
>
> It is recommended to **do this as soon as the task is done** — do not wait!

☐ STEP 4
If the **episode recorded is optimal, 'Save' it; if not, 'Discard' it**

> 💡 **TIP**
>
> It would be best to discard the episode recording if:
> - Your hand was in front of the camera feed.
> - One of the target objects was accidentally moved during recording.
> - The lighting condition was suboptimal or changed suddenly during the recording (e.g., the ring light was turned off).
> - The gripper or none of the target objects was visible at any moment during the camera feed.
>
> The number of successfully recorded episodes is indicated on the top-right corner.

☐ STEP 5
After every episode recording, you need to **calibrate F/T sensor** again to avoid drifting during guiding.

☐ STEP 6
You can then **'Start recording' another episode** (following the same steps detailed above for every recording).

☐ STEP 7
Once you have **recorded 50 episodes + 50 recovery episodes covering the steps above,** head back to the 'Details' screen of the skill and select **'Start cloud training'.** More details about this will be discussed in the section 'Cloud Training'.

WORD OF ADVICE

Experience shows that the **first few recordings could be difficult** for users who are new to the system. **Once you find your routine and what works for you, the process becomes much easier!**

Best Practices When Recording Motion Skills

- DO: **Every time you record an episode, choose a different starting position.**

- DO: **Every time you record an episode, expose MIRAI to various relevant variance.**
  This will **result in a more robust skill during execution.**
  - MIRAI does not learn from being shown the same thing twice or more times.
  - **Variations often relevant in automation tasks can include:**
    - Varying starting and ending points of trajectories
    - Varying the position of target objects in a task or during the manipulation of the working part.
    - Changing background or moving objects in the background (this is only relevant if the background is visible in the recorded episodes).
    - Differences in the color and/or shapes of the objects/working parts.
    - Changes in lighting conditions (e.g., changing intensity of daylight)
    - Imprecisions and variations in gripping positions at the TCP.

- DO: **Move with consistent speed:** MIRAI can pick up any speed changes (e.g., first move quickly and then move slowly); however, make sure there are **no pauses.**

- DO: **Include recovery episodes, which start in a position that is slightly off the target.** These will ensure MIRAI knows how to get back on track, i.e., move towards the target position, when it makes a mistake or finds itself in undesirable states.

- DO: **Train recorded 50 episodes (with relevant variance) + 50 recovery episodes at first,** then head back to the 'Details' screen and select **'Start cloud training' to get your first skill version.**[20] It is recommended to not record too many episodes before sending them to the cloud for training. See 'Cloud Training' for more details.

- DO: **Create backups of the data on your MIRAI Controller**
  It is good practice to occasionally create backups — especially once you have developed your skill to a satisfactory level. This will be very helpful if your Controller gets damaged or destroyed.

READ FURTHER

Check out this **link for information on how to create a backup of your MIRAI skills.**

20 For more details, see "MIRAI Cloud Training and Skill Versions" in the MIRAI User Manual for MIRAI Training or visit our Support Center.

- DO NOT: **Show two different routes to reach the same goal.** The system cannot decide which of the two ways would be the best. The best thing to do is to always go the shortest path from start to goal, wherever possible.

- DO NOT: **Add random motions or actions not related to the task.**

- DO NOT: **Move the target or introduce any variance during recording.**

Cloud Training

Once you have recorded the suggested number of optimal training episodes (we recommend at least 5 to 10 episodes for Positioning and Multi-target Positioning skills; at least 50 normal training + 50 recovery episodes for Motion skills), **you can proceed with cloud training.**

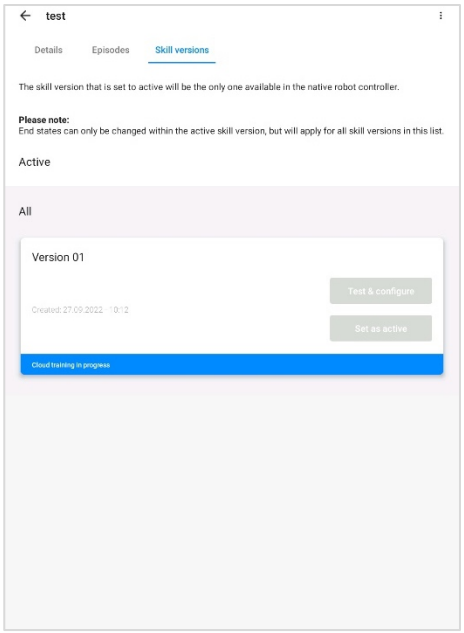
☐ STEP 1

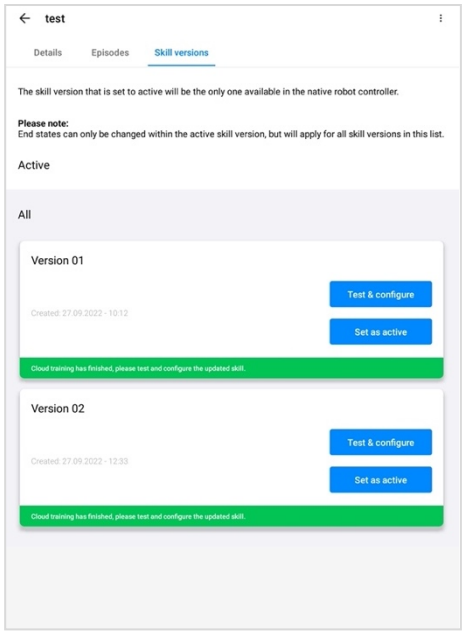
On your skill's **'Details'** screen, tap the **'Start cloud training'** button to begin. (Alternatively, you can also find this button on your skill's card in the 'Skill Overview' screen).

- Your first skill version (and your succeeding skill versions later) will appear under the 'Skill versions'[21] tab of your skill's dedicated page.
- Once cloud training has started, you will see 'Cloud training in progress' and the estimated time remaining written under the respective version. When using one (1) camera, the training time would take about 45 minutes; when using two (2) cameras, training would take about 1.5 to 2 hours.
- Once a skill version is available, you will see 'Cloud training has finished...' written in the green bar.

☐ STEP 2

When cloud training is done, **activate the skill version** you would like to work with, tap the **'Set as active'** button.





21 The 'Skill Versions' feature enables you to create different versions of the same skill to find out what works best for your use case. You can choose to activate one of the previous versions while still preserving older and newer versions.

Testing, Refining, and Embedding MIRAI Skills

Testing MIRAI Skills

Testing Newly Trained or Updated Skills[22]

Once you set a skill version to active, you can proceed with testing the skill to evaluate its abilities and competency level. We recommend choosing the best skill version for your application based on the tests you conduct.

TIP

While testing, we recommend **noting where MIRAI struggles or gets lost or what might not be working with a particular skill** — these should inform what kinds of **refinement episodes need to be recorded in order to create a more competent skill.**

☐ STEP 1
On the 'Details' screen of your skill, select the **'Test & configure'** button to begin the testing process.

☐ STEP 2
Select the **skill version you want to execute, test, and configure by clicking its corresponding 'Test & configure' button.**

☐ STEP 3
Guide the robot to a starting position that represents a scenario similar to the original starting positions used during training or is expected to be seen when the skill is executed in the real world. Like in the training process, select either **'Send to reference position'** or **'Manual positioning'** (when working without an F/T sensor, you must use the teach pendant to navigate the robot).

☐ STEP 4
Remove hands from robot to calibrate the F/T sensor, then **tap 'Calibrate F/T sensor'** to prepare the test session (skip this when not using a sensor).

☐ STEP 5
Check the image preview to ensure visibility (exactly as during training), then tap the **'Start Skill Execution'** button. When the skill reaches one of the end state conditions, it will automatically stop.

☐ STEP 6
Watch the execution of the skill. Observe and note how the robot interacts with the environment and where MIRAI is struggling.
- Press the 'Stop Skill Execution' if you need to temporarily stop the execution.
- Otherwise, if the skill reaches one of its end state conditions, it will automatically stop. The end state that stopped the execution will be displayed at the bottom of the screen.
- For either of the cases above, the **'Start Skill Execution' button should appear again,** and you can restart the skill once more when you are ready. Repeat STEPS 4 to 6 as needed.

22 For more details, see "Testing Newly Trained or Updated Skills" in the MIRAI User Manual for MIRAI Training

☐ STEP 7
You can then **'Start Skill Execution' again if needed and do more test sessions** (following the same steps detailed above for every testing session).
- If the skill behaves as intended in a variety of conditions, it is ready to be tested in production.
- If the testing phase shows weaknesses, this can be remedied through additional training, focusing on the situations that need improvement (see 'Refining MIRAI Skills' for related guidelines).

☐ STEP 8
For each skill, you must **configure its end state.** This can be done by tapping the 'Execution Settings' button found at the bottom of the 'Skill Testing' screen, selecting 'End States', then choosing and configuring your desired end state parameters (more details under 'Configuring End States').

WATCH

For more guidance on **testing skills,** you can also check out:
Testing Newly Trained or Updated Skills

Setting End State Triggers [23]

The end state is the condition which helps MIRAI understand that a skill has ended, and it must hand the control of the robot back to the native controller.

End state triggers must be set to detect and end the execution of a skill. To configure, go to the 'Skill versions' tab of the skill you want to set end states for, ensure that the skill version you will use is active, then select 'Test & configure'. On the next screen, select 'Execution Settings' at the bottom, then tap the 'End States' afterwards. Enable the end states you want to utilize, then configure them accordingly by following their specific instructions below.

End States	Best Use Cases	Configuration
Visual End State Recognition (Smart Detection): This smart feature allows MIRAI to automatically determine when the skill should end by comparing the current live camera feed with the scenes or images recorded during training.	• most cases (and therefore, can be enabled and tried first) • when it is unclear which end state is the best • when the visuals are clearly defined within the camera's field of view	Set a threshold value by using the slider or entering a value (from 0 to 1; a higher value = positioning at the end of the skill must match images from the live camera feed as precisely as possible, a lower value = the skill could stop significantly before the end state.)
Proximity-based: When the robot gets close to its target, this informs MIRAI that the end state has been successfully reached based on the set threshold values (distance and orientation). *Note:* This end state can only be used for positioning skills.	• most cases (and therefore, can be enabled and tried first) • when it is unclear which end state is the best • when the visuals are clearly defined within the camera's field of view	Set values for the proximity thresholds (both in mm and degrees). Enter the distance values from the target position based on where you want the skill execution to stop. | *Note:* The skill will only stop executing when all the specific criteria are met.

23 For more detailed instructions, see "Setting End State Triggers" in the MIRAI User Manual for MIRAI Training

TCP Force-based: When the force measured at the TCP exceeds (above or below) a certain force threshold, this tells MIRAI that the end state is successfully reached. *Note:* This end state is not available when working without an F/T sensor.	*For tasks which end by:* • touching a surface (e.g., end points for surface measurements or insertion) • stopping a surface interaction (e.g., by reaching the end of a working area) • dropping a part (e.g., after picking)	Enter a force value (from 0 to 100 Newtons), then define whether the skill should be stopped above or below this value, as measured at the F/T sensor. |
TCP Speed-based: When the movement at the TCP exceeds (above or below) a certain speed threshold, this tells MIRAI that the end state is successfully reached.	*For tasks which end by:* • slowing down or stopping when reaching a target position in space • stopping after a successful insertion • slowing down when reaching the end path (e.g., gluing, painting, etc.)	You must enter a speed-based threshold value (from 0.1 to 100 (cm/sec)), then select whether the skill should be stopped below or above the speed value you entered.
TCP Position-based (Beta): MIRAI recognizes the desired end state when the end effector crosses a defined plane. *Note:* This feature is released as a 'beta' version (accuracy is at ±5mm on low speed setting (≤1)).		Move the robot arm to a position where the threshold should be defined, then tap 'Set position' — the X, Y and Z values will automatically update. Then select an axis (X, Y, or Z), and the threshold would be perpendicular to that.
Anomaly-based: An anomaly-based end state halts skill execution if the current image looks unfamiliar (based on a threshold set). Using this can increase the reliability of your skill, by detecting conditions not encountered during training (e.g., changes in the lighting of an environment, tooling setup, materials used in production).	We recommend testing and iterating different thresholds to find what works best for your skill. Once you find a good threshold, it would be best to enable this end state in all cases.	Set an anomaly score threshold (from -5.0 to 0.0) by using the slider. A lower number will make the skill less sensitive to unfamiliar images, while a higher one will increase sensitivity. | *Note:* Selecting values at either end of the scale can cause the end state to never stop your skill (-5) or continuously stop your skill (0_, That said, it would be best to avoid choosing these extreme values.

⚠ IMPORTANT

- All end state options can be used in parallel. In case these triggers are used simultaneously, the condition that is met first will trigger the desired end state.
- End states need to be configured on every MIRAI Setup. This is especially important when syncing a skill created on another controller, since the end states are not shared.
- All "old" skill versions, (i.e., those created on a MIRAI controller(s) with a software version lower than 16.0.0) do not have the proximity-based and anomaly-based end states available.[24]

🎬 WATCH

For more guidance on **configuring end states**, you can also check this video:
End States (Or How to Stop a Skill)

24 For more detailed instructions, see "Setting End State Triggers" in the MIRAI User Manual for MIRAI Training

Refining MIRAI Skills

If you notice weak points during testing, you can record new episodes. Below are some key guidelines when recording refinement episodes:

- These can be shorter (30 to 45 seconds) than the initial episodes (vs 120 seconds).
- These can cover a smaller area than the initial episodes — specifically, focus on the weak spots or areas of variance you want to reach with MIRAI.

Recording more good episodes (and corresponding, more skill versions) can improve the confidence and competence of the skill you are working on.

Troubleshooting MIRAI Skills

Here are some of issues you might observe when testing skills and how they can be addressed:

Issue	What this indicates	Recommended resolutions
The robot avoids taking a direct path from some specific area to the target.	MIRAI has not been effectively shown how to move along a specific area.	*For positioning skills:* Record new episodes that show MIRAI a path from the target to this specific area, by moving the robot along this pathway to the area; make sure to rotate all axes of rotation along this pathway as well. *For motion skills:* Record recovery episodes that show MIRAI a path from this specific area to the target or trajectory, depending on the task.
The robot does not find its way to the target at all.	The current camera image is completely unknown to the skill, so MIRAI does not know how to get to the target from this area.	Check your hardware first, and determine: if your camera image appears normal, if there could be a reason that your camera image is blind, if the camera's mount or lens is broken, or the camera's light is of.
		If the camera image looks good, then check your training plan and determine if you forgot about the variance of your skill.
		If the training plan seems thorough, record new episodes which show MIRAI this area, by moving the robot to this area from the target position.
The robot appears to get lost and begins to drift away.	The robot has reached an area MIRAI has never seen, so MIRAI does not know how to reach the target from this area.	*For positioning and motion skills:* Record new episodes which show MIRAI this area, by moving the robot to this area from the target position.
The robot reaches a point near the target and then drifts away.	The camera may be slightly misaligned.	Use the camera re-alignment feature to return the cameras to their original configuration (revisit Composing Your Camera Setup if necessary).
	If the camera is aligned, MIRAI does not have enough information about the areas close to the target, and has not been	*For positioning skills:* Record new episodes showing MIRAI these nearby overshoot areas, by moving

	shown how to recover from an overshoot near the target.	the robot to these areas from the target position. *For motion skills:* Record new episodes showing MIRAI these nearby overshoot areas, by moving the robot from these areas to the target position.
The robot does not want to rotate toward the target using certain axes of rotation or joints.	MIRAI has not been trained to utilize specific axes of rotation when approaching the target from specific areas.	Record new episodes which show MIRAI how to utilize all available axes of rotation from each area, by moving the robot from the target to these areas, while also rotating the tool through each available axis.
The skill places the robot tool off-target in a consistent way.	If the skill is being performed on a new part / part variation, or a part that looks different than others MIRAI was trained on, MIRAI needs to be shown the new part / part variation.	Record new episodes using the new part or part variation.
	If the lighting has changed in your work environment, MIRAI has not been trained under the current lighting conditions yet.	Record new episodes under the current lighting conditions.
	The cameras may have become misaligned, or the aperture / focus may have changed (e.g., the mounting screws have loosened, the mounts got damaged, the set screws for the aperture / focus have fallen off the lens, etc.).	Use the camera re-alignment feature to return the cameras to their original configuration (revisit Composing Your Camera Setup if necessary).
	If none of the above apply, this may indicate that MIRAI has been taught bad data (e.g., it has been shown inconsistent start frames).	Once you delete the bad episodes, record new (good) episodes and retrain those in the cloud for a new skill version. Alternatively, request a data review from the Micropsi team so they can inform you of what episodes to delete.
The skill was working, but now it no longer works (e.g., the skill was good yesterday, but now the robot drives the tool to random positions or drifts with no aim).	The cameras may have become misaligned, or the aperture / focus may have changed (e.g., the mounting screws have loosened, the mounts got damaged, the set screws for the aperture / focus have fallen off the lens, etc.).	Use the camera re-alignment feature to return the cameras to their original configuration (revisit Composing Your Camera Setup if necessary).
	The robot's tooling may have been damaged (i.e., the parts in the camera's FOV such as the gripper fingers or the fixturing).	Investigate your robot's tooling, as well as the tooling in the workspace. If necessary, replace damaged parts.

Adding MIRAI Skills to Your Robot's Native Controller

- ☐ *Universal Robots:* Implement MIRAI Calls into the UR Polyscope program applicable.[25]
- ☐ *FANUC:* Add and synchronize trained MIRAI Skills on the FANUC controller.[26]
- ☐ *KUKA:* Add a MIRAI Skill in your KUKA program via the KUKA smartPAD.[27]

25 For complete details, see "Using MIRAI Skills with UR Polyscope" in the MIRAI User Manual for UR Integration
26 For complete details, see "Using MIRAI Skills with FANUC Teach Pendant" in the MIRAI User Manual for FANUC Integration
27 For complete details, see "Using MIRAI Skills with KUKA" in the MIRAI User Manual for KUKA Integration

Using MIRAI Skills on Different Setups: Shared Skills

MIRAI controllers which belong to the same network will automatically share their skills with each other — allowing you to use the same skill on different setups. [28]

To use a skill created on another MIRAI controller, you first need to synchronize that skill to your controller; at the same time, the hardware setup must be suitable for the skill.

☐ STEP 1

Ensure that the applicable MIRAI controllers are added to your network.

> ⚠ NOTE
>
> If you need assistance on adding a MIRAI controller(s) your network, please contact a Micropsi Industries representative.

☐ STEP 2

Ensure that your physical setup is complete and ready.[29]

- Robot & camera setup: It is highly recommended to use the same robot model and F/T sensor as the original skill's (if you trained without an F/T sensor, then you can sync without an F/T sensor as well, as long as the camera view looks the same as the original setup's). Additionally, ensure that the TCP displacement settings match.
- Camera's physical setup and settings: The number of cameras attached, the camera mount setup and the camera lenses used on the original skill must be the same.
- Tool setup: The end effector used and the tool's mass and CoG values must remain the same (though the latter may *slightly* differ after tool configuration).

☐ STEP 3

Proceed with 'Skill synchronization'.[30]

- To select a skill to 'Sync', go to the 'Skill Overview' page, and select the 'All Skills' tab. Then tap the 'Sync' button on the right side of the skill.
- Go through the 'Skill synchronization' process. This will involve five major steps (Physical Robot Setup, Tool Setup, Skill Information, Camera Settings & Alignment, Reference Position) — each of which the MIRAI app will guide you through.
- The 'Details' screen will then show the information of the shared skill. You may select what to do next (e.g., 'Record episodes', 'Start cloud training', or 'Test & configure'), similar to how you would work on a newly created skill.

28 For complete details on skill sharing, see "Shared Skills – Using a Skill on Different Setups" in the MIRAI User Manual for MIRAI Training
29 For the complete checklist to ensure your physical setup is ready for skill sharing, see "Preparing Your Physical Setup for Syncing" in the MIRAI User Manual for MIRAI Training
30 For the complete walkthrough, see "Syncing a Skill to Your Setup" in the MIRAI User Manual for MIRAI Training

Glossary

The list below definitions of key technical terms which appear on this document.

Technical Terms	Definition
Cloud training	Using a cloud-based machine learning service, Micropsi transforms episodes recorded and uploaded into a vision-based robot program — this results in a MIRAI skill. Cloud training can only be done when at least 5 successful episodes with at least 30 seconds worth of recorded data have been recording. Typically, cloud training takes approximately 45 minutes for a single-camera setup, and about 1.5 hours for a dual-camera setup.
End state	An end state is a condition that a user must set so that a MIRAI-powered robot knows when it should end the execution of a skill, and subsequently, when it should hand control of the robot back to the native controller. Within a robot task, there will be sections controlled by the robot's native controller (i.e., predetermined movements) and by the MIRAI controller (i.e., complex sections with variance). The native control program transfers control of the robot to MIRAI so it can handle the complex section (i.e., handover point). Once MIRAI is done with that section, it must hand over control back to the robot's native controller. Setting end states is necessary to be able to end the execution of a MIRAI skill.
Episode	To train a robot to perform a MIRAI skill, a user must perform camera recordings (through the MIRAI Training App, either manually or with the help of the Recording Assistant) of the area between target position(s) and starting position(s). These recordings, referred to as 'episodes', are then transformed into a MIRAI skill through cloud training.
Force/Torque (FT) Sensor	A Force/Torque (FT) Sensor is a robot tool which can detect linear (e.g., pushing, pressing, etc.) and rotational forces exerted upon it — i.e., it is the robot's sense of "touch".[31] It is attached to the robot's arm, just below the robot flange. The robot end effector or robot tool can then be attached to the F/T sensor.
Handover point or starting position	This is a designated location where a robot transfers control from its native controller to MIRAI; hence, allowing MIRAI to take over from the main robot program.
MIRAI skill	A MIRAI skill allows the MIRAI controller to perform certain tasks by imitating the motions and actions it was shown through controlled robot movements (i.e., via the episodes recorded); MIRAI skills are designed to deal with the dynamics and variances the user trained for in real time.
Overshoot	An overshoot occurs when a robot moves past, above, below, to the side of, or around the corner from an intended target the (e.g., the robot travels towards the target, but instead of reaching it continues to travel beyond it).
Reference position	When recording episodes or testing skills, users can define a safe and meaningful reference position for the tool center point. This will serve as a point of comparison that the robot knows it can go back to. In the MIRAI Training App, the reference position saved also serves as the reference photo that helps identify a skill.
Robot end effector or robot tool	The robot end effector or robot tool (e.g., grippers, suction cups, etc.) is a device that is attached to the end of the robot arm that interacts with the objects part of the task.

31 What is a force torque sensor? (Fierce Electronics)

Robot speed override	The robot speed override is a setting which affects how fast the robot moves while recording an episode.
Rotations	"A robot orientation is decided by a combination of rotations in X, Y, and Z direction, and we can have a 3-by-3 rotation matrix for each orientation."[32]
Rubber-banding	While recording an episode, "rubber-banding" refers to letting go of the robot (i.e., where the force(s) on the robot tool would then be equal to zero or nothing). This will result in MIRAI returning the robot tool to its starting position.
Skill version	A skill version becomes available once cloud training for a skill is enabled. Users can create different versions of the same skill to find out what works best for a specific use case.
Target position	The target position is the location a MIRAI-powered robot reaches at the end of a skill execution and hands control of the robot back to the native controller.
TCP displacement	This prevents undesired rotations and improves accuracy.
Tool Center Point (TCP)	"A Tool Center Point (TCP) is a point on the robot's tool. Each TCP contains a translation and a rotation relative to the center of the tool output flange."[33]
Translations	A robot translation involves movement along a straight path (i.e., when a robot moves from one point to another within a given space). Translations may occur along any of the three primary axes (X, Y, and Z).
Variances or variations	Variances include differences or deviations which MIRAI encounters while training or executing a skill. These can include: • Variations in the starting and end points of trajectories or target objects in the task or manipulation of the working part • Changing background or moving objects in the background (relevant if the background is visible in the recorded episodes) • Variations of the color(s) and/or shape(s) of the working parts • Changes in lighting conditions (e.g. changing daylight) • Imprecisions and variations in gripping positions at the TCP

32 Explanation on Robot Orientation (Universal Robots)
33 Tool Center Point (TCP) (Universal Robots)