User Manual MIRAI Training

How to train with MIRAI

VERSION 22.0.1

micropsi industries

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Introduction

Micropsi Industries' robot control system, MIRAI, allows users to automate complex motion tasks in dynamic process environments. MIRAI is a machine learning-based system that generates robot movements based on real-time image data and sensory input.

Today, most automation solutions are programmed using a scripting language or taught with a teach pendant and its user interface. In contrast, MIRAI trains robots to solve complex hand-eye coordination tasks by "watching" a human operator perform these tasks and imitating the observed actions.

Key advantages of MIRAI over traditional automation approaches include:

- 1. **Ease of Use:** MIRAI allows users to solve and automate complex motion tasks without requiring prior expert knowledge in automation, machine vision, or programming.
- 2. Adaptability: MIRAI's underlying machine learning technology can handle various sources of process variances and dynamics within the task and its environment. This capability allows the MIRAI controller to address new classes of tasks and problems in automation and robotics that previously required complex and expensive solutions or were impossible to automate.

To train the robot, the user manually scans the area between the target position and the intended starting position(s). These recorded demonstrations of motion paths are called *episodes*. For more complex tasks, the user performs and records multiple demonstrations by guiding the robot along a precise trajectory from different starting positions to the target position.

These episodes are then transformed into a vision-based robot motion program by our cloud-based machine learning service, creating a *MIRAI skill*. Skills allow the MIRAI controller to replicate the motions and actions previously demonstrated by the user, accurately steering robot movements and managing task variations in real time. Operating in a closed-loop system, the controller continuously receives feedback on the task environment and adjusts the robot's actions to guide the end effector to the target.

1 Safety Precautions

	Hazards during hand-guiding	
1	Squeezing or crushing: Caused by robot parts approaching fixed structures or rigid objects.	
2	Cutting or puncture: Caused by workpieces, tools, or structures with sharp edges or points.	
3	Shearing: Caused by moving robot parts approaching fixed structures or rigid objects.	
4	Burns: Caused by contact with hot surfaces of parts in the MIRAI setup.	
5	Strain or fatigue: Caused by long periods of hand guiding.	

During the training process, robot movement can be controlled by hand-guiding. When hand-guiding is activated, the robot can be moved in any direction. Follow all safety precautions to prevent injury.

- Be careful not to squeeze your free hand and fingers or shear any body parts.
- Pay extra attention when the robot is handling workpieces with sharp edges or sharp points, which can result in cuts or puncture wounds if the robot and human collide.
- Exercise additional caution if the robot is set to automatic mode to test the demonstrated movements. High-speed robot movements can crush body parts.

Lo Safety precautions

- ☑ When possible, use the automated recording assistant instead of hand-guiding.
- ☑ Wear safety gloves during training.
- ☑ Wear safety glasses during training, especially when workpieces have sharp edges or points.

2 The training setup

Every new MIRAI skill starts with the physical setup of the task environment: defining the skill's working area, mounting the cameras to observe this area, and adjusting the lighting conditions.

2.1 Plan the training setup

1 **Define the skill's working area.** This consists of two aspects:

- * Consider how the positions of relevant objects are expected to vary. What extreme positions will the robot move to while executing the task?
- * Consider the plausible robot trajectories. What motion paths will the robot follow to reach a variety of different plausible object positions?
- Set the "handover point" where the MIRAI skill will take over control from the main robot program. For example, in a table-top task, the handover point is typically a central position directly above the work area.

(3) Optimize the camera viewpoint:

- * MIRAI supports both wrist-mounted (dynamic) and floor-mounted (fixed) cameras, which can be configured as single or dual setups. A single wrist-mounted camera is effective for most tasks, including those requiring 3-D positioning.
- Position the camera(s) to capture changes in the position of the target object. The camera(s) should be positioned roughly perpendicular to the plane where precise positioning is needed.
- * Make sure that all task-relevant objects, including the target object(s) and the end effector, stay in view throughout the entire motion path.
- * Choose a viewpoint where visible background features remain constant over the skill's production lifetime. For example, the frame should show the work surface rather than the production flow. While reliable skills can be trained with varying backgrounds, this requires more time and effort to record sufficient episodes.
- For multi-target positioning skills, the camera(s) should be positioned roughly parallel to the robot tool, looking down along it and ideally showing the object (or part of it) closest to the tool center point (TCP).

(4) Choose the lighting scheme:

- * Consistent lighting conditions make it easier to train reliable skills. Training with varying lighting conditions requires more time and effort to record sufficient episodes.
- * Consider how lighting in the work area might change over the skill's production lifetime, including different times of day and seasonal variations.
- * Achieve consistent lighting with bright lights that neutralize shifts in ambient light.
- * For wrist-mounted cameras, use a bright ring light that moves with the camera.

2.2 Choose the MIRAI skill type

After planning your training setup, choose the type of MIRAI skill that will best execute your task. MIRAI can learn to move along arbitrary paths, reacting in real time to changes in the task environment.

There are three types of MIRAI skills:

- 1. Positioning skills
- 2. Multi-target positioning skills
- 3. Motion skills

i Note

- Positioning skills can be trained with or without a force/torque sensor.
- multi-target skills and motion skills must be trained with a force/torque sensor.

For details, refer to 3 Create a new skill.

2.2.1 Positioning skills

Positioning skills allow you to position the robot's tool center point in real time relative to a visible target, such as an object for picking or a workpiece for insertion. The robot follows the most direct trajectory to the target position, typically a straight path.

To use positioning skills, two conditions must be met:

- 1. The direct path from the handover point where MIRAI takes control to the target position must be free of obstructions.
- 2. The target object(s) must remain stationary during the MIRAI-controlled motion.

Typical use cases for positioning skills include:

- Placing a gripper in a pre-grip pose above an object that may vary in color, size, shape, or position
- Positioning a workpiece precisely for insertion in a subsequent step
- Placing a sensor tool relative to a workpiece for quality inspection

Positioning skills generally require less intensive training compared to motion skills, as they are highly robust with fewer recorded episodes. Training can be fully automated using the recording assistant, eliminating the need for a force/torque sensor.

2.2.2 Multi-target positioning skills

Multi-target positioning skills allow the robot to handle tasks involving multiple target objects. The robot moves in a straight, direct path towards the closest object.

Typical use cases for multi-target positioning skills include:

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

2.2.3 Motion skills

Motion skills allow the robot to perform more complex movements in real time. This is useful for a wide range of applications, such as insertion, contour following, picking objects from a moving conveyor, or tool positioning in crowded environments where a direct path is not feasible.

Typical use cases for motion skills are:

- Various insertion tasks, such as cable plugging
- Path- or contour-following tasks
- · Picking or placing objects from/on a moving conveyor
- Quality inspection tasks (positioning sensors or cameras)
- Finishing tasks like polishing or gluing
- Tool positioning where obstacles prevent a direct path from the starting point to the goal

Achieving robust motion skills involves thorough training, with repeated demonstration of precise movements across varied paths.

2.3 Set up the first training



Figure 1: Skill setup flowchart

Set up the robot and workspace:

- 1. Mount the camera(s), force/torque sensor (if using), and end-of-arm tool on the robot, as described in the Micropsi Industries Robot Integration Guide for your robot platform.
- 2. Jog or hand-guide the robot to the handover position.
- 3. Add adequate lighting, as chosen during planning.

Optimize the camera settings:

- 1. Open the MIRAI Training App and create a new skill (see chapter 3 'Create a new skill').
- 2. Inspect the live camera image displayed in the app:
 - Assess the field of view and ensure that the relevant objects remain in view throughout the intended motion.
 - Guide the robot to various points along the intended motion paths, while watching the image preview.
 - The target object(s) should remain entirely in view throughout the motion path, for every expected position of the target objects.
 - The robot's end effector should remain in view throughout the motion.
- 3. Determine the camera settings:
 - Try different camera holders and lenses until the field of view fulfills the above criteria.
 - Adjust the focus slightly beyond the end of the tool/manipulator, so the sharpest image occurs when the tool is about to touch the target object.
 - Adjust the aperture.
 - The middle value is generally adequate for most applications.
 - We recommend using even numbers for the aperture so that you can use the markings on the camera as a guide.
 - Closing the aperture reduces the lens opening, increasing the depth of field. This keeps more of the scene in focus, which is useful for keeping the target object sharp across the entire movement path. Conversely, opening the aperture blurs the background, which can also be beneficial during skill training. Additionally, closing the aperture reduces the light entering the camera, so you may need to adjust exposure settings to maintain proper brightness. Balancing these settings may require some experimentation.
 - Adjust settings in the MIRAI Training App:
 - Adjust the exposure time and gain to minimize over/under-exposure.
 - Guide the robot through some sample motions from start to target positions, to assess the exposure along the entire intended motion path.
- 4. Save the settings:
 - *On the camera:* Secure the focus and aperture settings using small screws on the lens. When the setup is complete, fix the screws with glue.
 - In the MIRAI Training App: Save the camera settings.

2.4 Quantify the Target Position

The goal of this step is to ensure you can recreate your ideal tool positioning above the target for future episode training sessions.

i Note

The ability to **recreate the ideal position above the target** is the key to obtaining good training data.

• Move the robot tool into the target position where the main robot program should take over from the trained MIRAI skill after the skill's execution.

- MIRAI's target position should not be directly on the workpiece the target position should be offset from the workpiece in such a way that the robot will have a clear path to the target object.
 - 1. 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.
 - 2. Example: If grabbing a part, the target position should place the gripper fingers at an offset
 of several millimeters above the part.



Figure 2: The ideal target position

- Quantify the robot tools target position where exactly is it in relation to the part? Measure distances and angles between the tool and the part.
- Take note of the movements that brought the robot into this position.
- Record any measurements or notes taken above.

2.5 Switch control between MIRAI and the robot

While training MIRAI, you may need to use the teach pendant to move the robot. For instance, you might jog the robot to precise target positions or make fine adjustments to positioning while assessing the camera settings.

If the robot control is used to move the robot, a disconnectivity popup will appear in the MIRAI Training App. To restore MIRAI control, ensure the necessary conditions are met, such as activating remote conrol or holding the deadman switch, depending on your robot platform. Then, press **Retry** to restore control to MIRAI and to resume the current screen in the app.



This option appears in the following MIRAI Training App screens:

- Camera settings
- Set reference position
- Recording episodes
- Recording assistant setup
- Testing skills

3 Create a new skill

A Important

To create a new skill in the MIRAI Training App, you must be connected to the Micropsi cloud. For information on how Micropsi Industries handles recorded data, refer to 12 Data FAQ.

3.1 Add a skill without a force/torque sensor

If your robot lacks a force/torque sensor, hand-guiding is unavailable for training. Instead, the recording assistant automates the process, allowing you to train positioning skills. Training other skill types requires a force/torque sensor. This section explains how to create a positioning skill without a force/torque sensor.

- 1 Tap **Add new skill +** to open the "Skill Selection" form.
- ⁽²⁾ In the first field of the form, enter a descriptive skill name that conveys the skill's purpose. Note that you cannot change a skill name after the skill has been created.
- ⁽³⁾ Select "Positioning" for the skill type. Note that although you can select motion or multi-target positioning skills on this screen, training these skills requires a force/torque sensor. Therefore, you must select "Positioning" here.

MIRAI Skill Overview	Co	← MIRAI Create Skill	
Local skills All skills	Add new skill +	Skill Selection - Step 1/4	
updated: 26.09.2023 - 15:45		Name of skill	
		Test Skill Positioning	
		Type of skill	
		Positioning Use for tasks that involve arrows the straight, direct path towards an object position. These skills are provided to the target is and the straight, direct path to the target is and the straight of the scanned episodes. Evaluation of the scanned episodes. Section 1997 Positioning of insertion tasks (direct path, no obstacles). Placing a gripper in a pre-grip pose over an object for picking. Positioning for insertion tasks (direct path, no obstacles). Placing a sensor tool for quality inspection	Multitarget (Internet for the set of the set
		Number of cameras	~
			Next \rightarrow

4 Select the number of cameras for your skill.

value of skill		
Test Skill Positioning		
Type of skill		
Positioning	O Motion	O Multi-target Beta
Use for tasks that involve a robot moving in a straight, direct path towards an object/position. These skills show high robustness with a few scanned episodes.	Use for complex non-linear motion tasks, when the direct path to the target is not possible. These skills are more demanding in terms of training.	Use for tasks that involve a robot moving in a straight, direct path towards multiple objects/positions.
Placing a gripper in a pri Positioning for insertion Placing a sensor tool for	e-grip pose over an object for pickin tasks (direct path, no obstacles) quality inspection	g
Number of cameras		-
single carnera positioning skill		

- 5 Tap Next to proceed to Step 2, "Skill Configuration."
- 6 Under "Robot Selection," select the robot for this skill from the **Robot** drop-down menu.

Skill Configuration - Step 2/4 Robot Selection Rot CRX-DUAL (coperimental) M-208/25 LR Mate 2000 LR Mate 2000/45 UR3 UR5 UR5 UR5 UR7 UR5 UR7 Extense Statematic State	← MIRAI Create Skill	۵
Rote: CRX-100AL UR3-100 UR3-100 UR3-100 UR3-100 UR3-100 UR4-100 UR4-100 UR3-100 UR3-100 <th>Skill Configuration - Step 2/4</th> <th></th>	Skill Configuration - Step 2/4	
Rotet CRX-100A/L CRX-00A/L (expermental) M-208/25 LR Mate 2000 LR Mate 2000/A5 UR3 UR3 UR3 UR4 UR5 UR4 UR4 UR5	Robot Selection	
GR2 104/L GR2 204/L (opprimental) M-208/25 LR Mate 2000/45 UR3 UR3 UR5 UR10 UR300 UR30 UR30	Robot	_
CRX 200A/L (experimental) M 200A/25 LR Mate 200D LR Mate 200D /4S UR3 UR3 UR3 UR3 UR10 UR3 UR10 UR3 UR3 UR3 UR3 UR3 UR3 UR3 UR3	CRX-10iA/L	
M 208/25 LR Mate 2000 LR Mate 2000/45 UR3 UR3 UR300 UR30 UR30 UR300 UR3	CRX-20iA/L (experimental)	1
LR Mate 2000 LR Mate 2000/45 UR3 UR3 UR3 UR4 UR4 UR4 UR4 UR4 UR4 UR4 UR4	M-208/25	
LR Mate 2000/4S UR3 UR3 UR3 UR3 UR3 UR3 UR3 UR3	LR Mate 200D	
UR3 UR3 UR10 UR20 UR30 UR30 UR30 UR30 UR30 UR100 UR100 UR100 UR100 UR100 UR100 UR100 UR30 UR30 UR30 UR30 UR30 UR30 UR30 UR	LR Mate 200iD/4S	
URS URSe URSe URICe URICE URICE URICE Configuration Forstations Posta	UR3	
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URSe URIte URIte Axis Configuration Transitions * satis * satis * satis * grants * gran	UR3e	-
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Image: seads Image: seads Rotations Image: seads Image: seads Image: seads	Translations	
Rotations ● (a) None (b) Single axis (c) 3 axis (c) Back (c)	x-axis y-axis z-axis	
● None ○ Single-axis ○ 3-axis ← Back Nont ⇒	Rotations	
← Back Next →	None Single-axis 3-axis	
	← Back Next	: >

- 7 Under "Device Configuration:"
 - Select None from the Force/Torque Sensor drop-down menu.
 - Select the camera(s) from the drop-down menus.

Skill Configuration - Step 2/4	
Robot Selection	
Robot	
UR5e	~
Device Configuration	
Force/torque Sensor	
None	~
Camera 1	
Ximea - 3651	~
Camera 2	
Ximea - 5351	~
How are cameras mounted?	
Wrist mounted Static mounted	
Avia Configuration	
Axis conliguration	
Iranslations	
🖾 x-axis 🖾 y-axis 🖾 z-axis	

If the desired cameras do not appear in the drop-down menus, check that they are installed, connected, and powered on. If you connect a new camera, restart the MIRAI controller to ensure it detects the change correctly.

- USB camera(s): Ensure the camera(s) are connected to the USB port(s) of the MIRAI controller.
- *GigE camera(s):* Ensure that the IP address of the camera(s) is set to the correct subnet and that each camera is selected in the MIRAI Training App's network settings. For instructions on configuring GigE cameras, consult the Robot Integration Guide for your robot platform.

A Important

Skills that were trained with USB cameras cannot be executed with GigE cameras, and vice versa.

(8) Under "How are cameras mounted?", the "Wrist mounted" option will be preselected.Static-mounted cameras are only possible for motion skills.

Robot	
UR5e	~
Device Configuration	
Force/torque Sensor	
None	~
Camera 1	
Ximea - 3651	~
Camera 2	
Ximea - 5351	~
How are cameras mounted?	
Wrist mounted Static mounted	
Axis Configuration	
Translations	
🗹 x-axis	
Rotations	
None Single-axis 3-axis	

Under "Axis Configuration," translations settings will be deactivated for positioning skills. Note that you can train robot movements using rotations based on the specified action frame (dynamic TCP or static robot base). However, enable all axes only when necessary to limit degrees of freedom and ensure stability.

- MIRAI Ci	eate Skill d
Camera 1	
Ximea - 3651	~
Camera 2	
Ximea - 5351	~
How are carrier	as mounted?
Axis Configi	iration
🗹 x-axis	y-axis
Rotations ()	Single axis
Around:	axis Around y-axis
We strongly re e.g. between th	commend displacing the TCP from the center of the robot's tool flange to the end of the tool e fingertps of a gripper. This prevents undesired robotions and improves accuracy.
🗌 TCP displa	sement from center of tool flange

- (10) Some tasks require changing the center of rotation to the tool center point (TCP) or an alternative reference point. We recommend displacing the TCP from the tool flange center to the tool's end to prevent undesired rotations and improve accuracy.
 - To do this, tick the check box **TCP displacement from center of tool flange**.
 - Enter the X, Y, and Z displacement values.

- Select **degrees** or **radians**, then enter RX, RY, and RZ angular values to specify the TCP displacement in reference to the center of the tool flange.
- Use the teach pendant to find these values, if available.

Around x-axis	Around y-axis	Around z-axis	
Note: When tool rotatic select the respective to It is highly recommend	ins are selected, the center of gravity of you would like to use or go to the " led to enable all axes only when requ	needs to be taken into considerat fool Configuration section to set u uired.	ion. Please p a new tool.
Select the respective	tool or set up a new tool		
Tool			
			~
	Go to tool confi	guration	
We strongly recommer e.g. between the finger	id displacing the TCP from the cente tips of a gripper. This prevents under	r of the robot's tool flange to the e sired rotations and improves accur	nd of the tool acy.
We strongly recommer e.g. between the finger TCP displacement Position	id displacing the TCP from the cente tips of a gripper. This prevents under t from center of tool flange	r of the robot's tool flange to the e irred rotations and improves accur 7 (mm)	nd of the tool acy.
We strongly recommer e.g. between the finger TCP displacement Position X (mm)	ed displacing the TCP from the cente tips of a gripper. This prevents under t from center of tool flange Y (mm)	In of the robot's tool flange to the e sired rotations and improves accur Z (mm)	nd of the tool
We strongly recommerce, g. between the finger TCP displacement Position X (mm) 0	ed displacing the TCP from the center tips of a gripper. This prevents under t from center of tool flange Y (mm) 0	r of the robot's tool fange to the entropy of fange to the entropy of the entropy	nd of the tool
We strongly recommender e.g. between the finger Position X (rm) 0 Orientation Please enter the value Ty ou are using a UR and enter them in the Unit of measure @ addians @ de	d daptacking the TCP from the center ges of a grapher. This prevents united from center of tool flange V (mm) 0 s for angular displacement belo bobly to may use their TCP of flatts behav.	et the robots tool flamps to the accurate interformations and improves accurate interformations and improves accurate of a contract of the second sec	nd of the tool acy.
We strongly recommender C TCP displacement Position X (mm) 0 Offentation Offe	d daplacing the TCP from the center op of a gripper. The prevent states the prevent states (from center of tool flamper y (mm) 0 s for angular displacement beto beto beto y below. gree RY (rad)	ed the solution of lange to the solution and improves accurate instances and improves accurate the solution of	nd of the tool acy:
We strongly recommen- es, between the finger Commentation Position V (rmm) 0 Orientation Please are the value and enter them in the Unit of measure (R) (rad) 0	d daptaong the TCP from the center ope of a grigore. This prevent united throm center of tool flange V (mm) 0 e for angular displacement belo bobt, you may use their TCP of flange prece RY (rad) 0	c of the solution of flags to the solution interferentiations and reproves accurate 2 (mm) 0 ww. metation wizard to calculate t R2 (rss) 0	nd of the tool

- 11 Tap **Next** to proceed to Step 3, "Camera settings."
- (12) Enter the gain and exposure settings for each camera. You must adjust the focus and aperture physically on the lens itself. The aperture ranges from 1.4 to 16; a value of 8 is recommended. Adjust the focus of the lens so that in the camera feed the tip of the end effector is in focus. **These settings are universal and should be used for all skills.**

🛕 Warning

If you change these settings after training skills, it break those trained skills!



- (13) Once the settings on the camera lens are done, adjust the camera exposure time and gain in the training app to minimize over/under exposure. Jog the robot through the trajectories that the robot will likely take to check and adjust the camera settings to values that offer a good lighting range and sufficient contrast. Tap **Apply settings** and then **Next** to proceed to Step 4, "Reference Position."
- ⁽¹⁴⁾ The reference position is the position the robot returns to record a new episodes or test skills. Choose a safe and meaningful reference position for the tool center point by guiding the robot to the desired position and tapping **Save position**.

MIRAI Reference position	Skill: Test Skill Positioning (0)
Reference Position - Step 4/4	
^{color_vision_1}	ion that will be saved
as the reference position.	on that will be saved
≚ Save positio	n
← Back	Finish

⁽¹⁵⁾ Tap **Finish** to create the skill. On the "Skill Overview" screen, confirm that the skill you created appears under both the **Local skills** and **All skills** tabs.

- Local skills are all skills created on the MIRAI Controller you are currently using and skills you have previously synchronized from other controllers in your network.
- **All skills** includes all skills across all MIRAI controllers in your network. These include skills that are available for synchronization and all local skills.
- For information on synchronizing skills, see 9 Shared Skills Using a Skill on Different Setups.

You can now record your first training episode. For details, see 4 The Training Loop - Recording Episodes.

MIRAI Skill Overview	MIRAI Skill Overview
Local skills All skills Last updated: 26.09.2023 - 16:27	Local skills All skills Add new skill + Last updated: 26.09.2023 - 16:27
Test Skill Motion Motion skill Modifie: 200 2023 - 0402 Skill versions 01 Courd episodes 5 Local episodes 5	Test Skill Motion Motion skill Modifiet: 209 2029 - 0402 Skill versions 01 Cloud episodes 5 Local episodes 5
Test Skill Positioning Positioning skill Medified: 200 2022-00.5 Skill versions 01 Color grindles: 5 Color grindles: 5	Test Skill Positioning Positioning skill Modified: 2609.0029 - 0058 Skill versions 01 Cloud repinders 3 Local epinders 5
	Test Skill MTP Multi-target positioning skill @##s Lat cloof raining %IA_Skill versions 0 Closef episodes 0 Local episodes 0
	Test Skill Positioning 2 Positoning skill Last cloud replaceders 3 Local episoder: 0

3.2 Add a skill with a force/torque sensor

i Note

To be able to create skills which are trained through hand-guiding (Multi-Target Positioning skills and Motion skills), **you need a Force/Torque sensor in your robot setup**. Positioning skills can be trained by hand-guiding or using the recording assistant.

Selection - Step 1/4
skill
I Positioning
kill
 Itining The formation of the second se
f cameras ✓ Next →
נ ו ו ג נ ביונס ו ו ג נ כיוו ג נ ק

- 1 Select a skill type. MIRAI offers three types of skills:
 - **Positioning skills:** Use for accurate real-time positioning of a tool where the path is a straight, direct motion from the starting point to the target position.
 - **Multi-target Positioning skills:** Use for tasks that involve a robot moving in a straight, direct path towards multiple objects or positions.
 - **Motion skills:** Use for complex non-linear motion tasks, or where the direct path is not possible, such as avoiding around an obstacle or following a path.

i Note

For more information on the different skill types, see Choose the MIRAI skill type.

2 Select the skill type by tapping on the appropriate button

Test Skill Positioning		
'ype of skill		
Positioning	O Motion	O Multi-target Beta
Use for tasks that involve a robot moving in a straight, direct path towards an object/position. These skills show high robustness with a few scanned episodes.	Use for complex non-linear motion tasks, when the direct path to the target is not possible. These skills are more demanding in terms of training.	Use for tasks that involve a robot moving in a straight, direct path towards multiple objects/positions.
Use case examples:	re-orio pose over an object for pickin	a
Positioning for insertio Placing a sensor tool f	n tasks (direct path, no obstacles) or quality inspection	*

MIRAI Create Skill	<i>C</i> o
Skill Configuration - Step 2/4	
Robot Selection	
Robot	
CRX-10iA/L	
CRX-20iA/L (experimental)	Ĩ
M-20iB/25	
LR Mate 2000	
LR Mate 200iD/4S	
UR3	
UR5	Ĩ
URID	
UR3e	
UR5e	
UR10e	
UR16e	
Axis Configuration	
Translations	
🗹 x-axis	
Rotations	
None Single-axis 3-axis	

bot Selection ot	
ot	
t5e	~
vice Configuration	
ce/Torque Sensor	
Robot	~
nera 1	
mea - 2751	~
nera 2	
mea - 2551	~
v are cameras mounted?	
Wrist mounted Static mounted	
s Configuration	
nslations	

i Note

selecting the static-mounted option will significantly affect rotation behavion and should only be done if necessary. This means rotations and actions defined in the next section will reference the robot's fixed base frame (coordinate system) instead of the TCP's relative action frame, which is standard for wrist-mounted setups.

MIRAI Create Skill	<u>_</u>
Skill Configuration - Step 2/4	
Robot Selection	
Robot	
UR5e	~
Device Configuration	
Force/Torque Sensor	
OnRobot	~
Camera 1	
Ximea - 2751	~
Camera 2	
Ximea - 2551	~
How are cameras mounted? Wrist mounted Static mounted	
Axis Configuration	
Translations	
x-axis y-axis Z-axis	
	Mart N

3 You can train robot movements on all the three translational axes i.e., movement along the x, y or z-axis. De-selecting one or more axes will prevent the robot to move along that axis. Please do this

only when the range of the robot's movement needs to be restricted. It is not possible to disable all the 3 axes because this would cause the robot to remain stationary. (This feature is disabled for positioning skills.)

← MIRAI Create Skill Ć	0
Skill Configuration - Step 2/4	
Robot Selection	
Robot	
UR5e V	
Device Configuration	
OnRobot ~	
Camera 1	
Ximea - 2751 ~	
Camera 2	
Ximea - 2551 ~	
How are cameras mounted? Wrist mounted Static mounted	
Axis Configuration	
Translations	
← Back Next →	

4 You can also train robot movements using rotations. This will allow you to move and rotate the robot arm with reference to the action frame that was specified in the step before (i.e., the dynamic TCP action frame or the static robot base frame). It is highly recommended to only enable all axes when it is really required, to limit the degrees of freedom and ensure the trained trajectory is stable.

i Note

For motion skills only one rotational axis can be enabled; for positioning skills, you can enable all three axes

- MIRAI Create Skill	<u>د</u>
Axis Configuration	
Translations	
🗹 x-axis 🔽 y-axis	
Rotations 0	
None Single-axis 3-axis	
Select an axis:	
Around x-axis Around y-axis Around z-axis	
select the respective tool you would like to use or go to the Tool Configuration section	to set up a new tool.
It is highly recommended to enable all axes only when required. Select the respective tool or set up a new tool	
It is highly recommended to enable all axes only when required. Select the respective tool or set up a new tool Tool	~
It is highly recommended to enable all area only when required. Select the respective tool or set up a new tool Tool Go to tool configuration	· ·
It is highly recommended to enable all axes only when required. Select the respective tool or set up a new tool Tool Oo to tool configuration Rotations around Tool Center Point (TCP)	
It is highly recommended to enable all axes only when required. Select the respective tool or set up a new tool Tool Go to tool configuration Rotations around Tool Center Point (TCP) We strongly recommend displacing the TCP from the center of the robot's tool flagrage a, between the fingerity of a groupe. This prevents underned valuous and implo	V to the end of the tool
t is highly recommended to enable all axes only when required. Select the respective tool or set up a new tool Tool Go to tool configuration Rotations around Tool Center Point (TCP) We strongly recommend displaying the TCP from the center of the robots tool flange If TCP displacement from center of tool flange	to the end of the tool

⁽⁵⁾ When rotations are enabled, you are also required to specify the respective tool in use. From the 'Tool' dropdown, select an existing tool, or tap 'Go to tool configuration' to set up a new tool. (See section 3.2.1 Tool configuration for more details.)

Around x-axis	Around y-axis Aroun	d z-axis
Note: When tool rotation select the respective tool It is highly recommende	is are selected, the center of gravity needs to you would like to use or go to the Tool Con of to enable all axes only when required.	o be taken into consideration. Please figuration section to set up a new tool.
Select the respective to	ool or set up a new tool	
Tool		
		~
	Go to tool configuration	1
We strongly recommend e.g. between the fingerti	I displacing the TCP from the center of the ps of a gripper. This prevents undesired rota	obot's tool flange to the end of the tool tions and improves accuracy.
Rotations around " We strongly recommend e.g. between the fingerti TCP displacement Position	Looi Center Point (TCP) displacing the TCP from the center of the ps of a gripper. This prevents undesired rots from center of tool flange V (rom)	vobats tool flange to the end of the tool tions and improves accuracy.
We strongly recommen e.g. between the fingerti CP displacement Position K (mm) 0	I displacing the TCP from the center of the so of a spiger. This prevents undesired rots from center of tool flange Y (mm) 0	coborts tool flange to the end of the tool does and improves accuracy.
Rotations around ' We strongly recommence e.g. between the fingeri TCP displacement Position x (rmn) 0 Jrientation Pease enter the values f you are using a UR to and enter them index of the value or adding of the displacement or adding of the displacement	Idoi Center Point (ICP) idaplacing the TCP from the center of the to of a optiger. The prevents undesked rold from center of tool flange V (mm) v (mm) for angular displacement below. bot you may use their TCP Orientatio dis below. ee RY (rad) 0	zbots tool fungo to the and of the tool cores and improves accuracy.

← MIRAI Camera Settin	ngs	Skill: mtp case 3 non pick (0)
Camera Settin	gs - Step 3/4	
	H	
color_vision_1		
Minimize over/ (1–15) and exp seconds).	/under exposure b posure time (100–	y adjusting gain 15,000 micro
Gain	Exposi	ure (µs)
Apply settings		
← Back	Settings applied	Next >



	≚ Save position	
← Back	Position saved	Finish



MIRAI Skill Overview) IRALI Skill Overview	۵
Local skills All skills Last updated: 26.09.2023 - 16:27	Local skills All skills Add new s Last updated: 26.09.2023 - 16:27	dll +
Test Skill Motion Motion skill Option Skill Versions 01 Cloud episodes 5 Local episodes 5	Test Skill Motion Motion skill Modifiel: 3:09 2023 - 04 02 Skill versions 01 Cloud episodes 5 Local episodes 5	:
Test Skill Positioning Positioning skill Modifiet: 20:00:203-00:38 Skill versions 01 Cloud episodes 5 Loud episodes 5 Cloud training in progress 1 hour and 15 mainutes remaining	Test Skill Positioning Postioning skill Open Modified: 20.052023-003 Skill versions 01 Cloud relations 5	ł
	Test Skill MTP Multi-target positioning skill (@ess) Last doed training \1/A. Skill versions 0 Cloud reptodes 0 Local reptodes 0	:
	Test Skill Positioning 2 Positioning skill Last dowd rawing N/A Skill versions 0 Cloud repisodes 8 Local repisodes 0	:

3.2.1 Tool configuration

i Note

Tool configuration is required only if using a force/torque sensor. To configure tools for skills, ensure that rotations are activated and a force/torque sensor is configured.

This section explains how to configure different tools to use in your setup, particularly for skills with rotations. You can manually enter tool characteristics or use the measurement wizard to estimate the center of gravity (CoG) using force/torque measurements in different positions. Follow these steps to configure a tool.

Step 1: Open the Tool Configuration screen

Expand the main menu and tap **Tool Configuration** or access the screen from the "Create Skill" section.



Step 2: Add a new tool

This screen displays all available tools. If no tools are configured, the table will be empty. To add a new tool, tap **Set up new tool +**. You can modify an existing tool by tapping **Edit**.

set up a new tool or or Tool Name	Mass	CoG CX	CoG CY	CoG CZ	
gripper	2.00 kg	0.00 mm	0.00 mm	10.00 mm	Edit
		Set up new to	iol +		

Step 3: Enter tool name and set robot

Enter a descriptive name for the tool in the "Tool name" field. From the "Robot name" drop-down menu, select the robot in use.

	configuration – CoG and M	Wass		_	☐ MIRAI Tool	configuration – CoG and I	Mass	
Tool Mass	& Center of Gr	ravity (CoG)			Tool Mass	& Center of G	ravity (CoG)	
Tool name				_	Tool name			
gripper					gripper			
Robot name					Robot name			
			~		UR5			~
Mass in kg:	CoG CX in mm:	CoG CY in mm:	CoG CZ in mm:		Mass in kg:	CoG CX in mm:	CoG CY in mm:	CoG CZ in mm:
	Start mea	asurement process				Start mea	asurement process	
← Back					← Back			

Step 4: Enter tool information

If you have the tool information, you can enter it manually. If you do not have the information, use the measurement wizard.

To manually enter tool information:

Enter the mass and the values for the X, Y, and Z coordinates for the tool's center of gravity. Tap **Save and proceed**.

To use the measurement wizard: Follow the steps below.

1 Tap Start measurement process to open the measurement wizard.

Тоо				
Robot				
UR5e				~
F/T Sensor				
OnRobot				\sim
if you already know v process. Otherwise, le	alues for mass, CoG CX, 0 ave these fields empty ar	CoG CY and CoG CZ, input nd go through the measu	ut them below and skip irement process.	his:
Mass in kg	CoG CX in mm	CoG CY in mm	CoG CZ in mm	
	Start mea	surement process		
Note				
The tool me	asurement process is only a	vailable when a force/torqu	e sensor is connected.	

- ⁽²⁾ The first screen explains how to measure the CoG by moving the robot to six poses, as shown in the illustrations. Move the robot according to your robot platform.
 - **Universal Robots:** Use the robot's freedrive to move the arm, holding the arm above the force/torque sensor, not below. Avoid grabbing the tool to move the arm.
 - **FANUC:** Jog the robot in T1 mode while holding the deadman switch.
 - **KUKA:** Run MiraiAppControl on the KUKA smartPAD, with the enabling switch and start key pressed. The [S][I][R] indicators should all be green. Follow the steps in the MIRAI User Manual for KUKA Integration to measure mass and center of gravity.

After reading the instructions, tap **Proceed**.

Tool measure	ement process				×
Measur	ement Pro	cess - Instr	uctions		
How it wo	orks				
The created t A minimum o measuring th	ool needs to be conf f 6 poses (+/- x, y & e gravity of the tool a	igured (in terms of r z) are required to ge at each pose.	nass and CoG), spe t a reasonable valu	cifically for rotation e for the CoG and m	s. nass by
The next 6 st	eps guide you throug	h the required tool j	ooses. Refer to the i	lustrations shown.	
Important: us	se the robot's own ir	iterface to move th	e robot; MIRAI han	d-guiding is disable	ed.
Always keep i tool when doi	in mind to move the	robot by the robot a	rm (above the force t when taking each	/torque sensor) and measurement.	d not to grip the
Pose 1	Pose 2	Pose 3	Pose 4	Pose 5	Pose 6
	дÊз		₩¢		

3 Prepare the robot for the measurement process by positioning it with the last joint pointing straight down, as shown in the illustration. When the robot is in the correct position, tap **Robot is ready**.

Tool measurement process	×
Measurement Process – Prepare the robot	st downwards on in the
To begin, make sure the robot is positioned with the last joint pointing straigh illustration below.	t downwards, as in the
7	\$
, EG	
← Back	Robot is ready

4 Start Pose 1. Take the first measurement in the starting position with the tool pointing straight down, as shown in the illustration. Wait 5-10 seconds for the force/torque sensor to attain a static state. Tap **Measure**.

roor measurement process		×
Measurement Pro	ocess - Pose 1/6	
	PT	
	<u> </u>	
	M 7	
	Έď	
Instructions Pose 1		
Take the first measurement in the	his starting position with the tool pointing straight downwards (as show	νn
Take the first measurement in t in the illustration above). After p "Measure".	his starting position with the tool pointing straight downwards (as show ositioning the tool, keep your hands away from the robot and tap on	m
Take the first measurement in the illustration above). After p "Measure". Important: use the robot's own	his starting position with the tool pointing straight downwards (as show ositioning the tool, keep your hands away from the robot and tap on interface to move the robot; MIRAI hand-guiding is disabled.	n
Take the first measurement in th in the illustration above). After p "Measure". Important: use the robot's own Note: Always move the robot I	his starting position with the tool pointing straight downwards (as show oosticning the tool, keep your hands away from the robot and tap on interface to move the robot; MIRAI hand-guiding is disabled.	m
Take the first measurement in the in the illustration above). After proceedings of "Measure". Important: use the robot's own Note: Always move the robot I when making pose changes.	his starting position with the tool pointing straight downwards (as sho estorming the tool, keep your hand as well your the not beet and top on interface to move the robot; MIRAI hand-guiding is disabled, by the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the in the illustration above). After pro- Measure", Important: use the robot's own Note: Always move the robot when making pose changes.	his starting position with the tool pointing straight downwards (as sho estioning the tool, key your hands away from the robot and top on interface to move the robot; MIRAI hand-guiding is disabled. by the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in di in the illustration above). After p "Measure". Important: use the robot's own Note: Always move the robot when making pose changes. Measure	his starting bootien with the too bootings straight downwards (as sho solitioning the tool, keep your hands away from the robot and top on interface to move the robot; MIRAI hand-guiding is disabled. by the robot arm (above the force/torque sensior) and don't grip the tool	vn
Take the first measurement in the intellustration above). After p Measure'. Important: use the obot's own Note: Always move the robot I when making pose changes.	his starting the position with the too be pointing straight downwards (as sho satisfing the tool, keep your hands away from the robot and top on interface to move the robot MIRAI hand-guiding is disabled. by the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the flustration above). After pro- Measure . Important: use the robot's own . Note: Always move the robot to when making pose changes. Measure	his starting position with the tool pointing straight downwards (as sho externing the tool cyron than daw with runn the robot and top on interface to move the robot; MIRAI hand-guiding is disabled. By the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the likitration above). After pro- Measure	his starting position with the tool pointing straight downwards (as sho selectioning the tool, keep your hand as with your the herobet and tap on interface to move the robot; MIRAI hand-guiding is disabled. By the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the flustration should have be found to be a straight of the flustration of th	his starting position with the tool pointing attraight downwards (as sho selectioning the tool, keep your hands away from the robot and top on interface to move the robot; MIRAI hand-guiding is disabled, by the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the flustration should have be the flustration should have the flustration should be note: Always move the robot when making pose charges.	his starting position with the tool pointing straight downwards (as sho esticationing the tool, keep your hands away from the robot and top on interface to move the robot; MIRAI hand-guiding is disabled. by the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the flustration above). After provide the flustration above). After provide the robot is own important use the robot is own Note: Always move the robot when making pose changes.	his starting position with the tool pointing straight downwards (as sho sectoring the tool karp your hand as with your the noted tart on interface to move the robot; MIRAI hand-guiding is disabled. By the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the flustration should have provide the flustration should have provide the robot's own Important: use the robot's own Note: Always move the robot when making pose changes.	his starting position with the tool pointing straight downwards (as sho sectoring the tool carrier beyon I hand away (from the robot and tap on interface to move the robot; MIRAI hand-guiding is disabled. By the robot arm (above the force/torque sensor) and don't grip the tool	vn
Take the first measurement in the flustmine show). After provide the flustmine show). After provide the flustmine show is the robot's own important: use the robot's own Note: Always move the robot when making pose changes. Measure	his starting position with the tool pointing straight downwards (as sho sectoring the tool, keep your hand as with your the her obta and top on interface to move the robot; MiRAI hand-guiding is disabled. By the robot arm (above the force/torque sensor) and don't grip the tool	vn

- 5 When the measurement is done, a green "Measurement successful" message will appear. This takes a few seconds. Tap **Next pose** to proceed.
- 6 For Pose 2, position the robot with the tool in a horizontal position facing right or left, as illustrated. Wait for 5-10 seconds and tap **Measure**. Then tap **Next pose**.

Tool measurement process		×
Measurement Pr	ocess - Pose 2/6	
	TE	Ъ Р
	M	
Instructions Pose 2		and the state of the state of the state state of the stat
Instructions Pose 2 Bring the tool in a straight hori: After positioning the tool, keep	contal position facing to the right or your hands away from the robot and	left (as shown in the illustration above). I tap on "Measure".
Instructions Pose 2 Bring the tool in a straight hori: After positioning the tool, keep Important: use the robot's ow	contal position facing to the right or l your hands away from the robot and n interface to move the robot; MIRA	left (as shown in the illustration above). I tap on "Measure". Il hand-guiding is disabled.
Instructions Pose 2 Bring the tool in a straight horiz After positioning the tool, keep Important: use the robot's own Note: Always move the robot when making nose changes	contal position facing to the right of I your hands away from the robot and n interface to move the robot; MIRA by the robot arm (above the force/to	left (as shown in the illustration above). I tap on "Measure". I hand-guiding is disabled. prque sensor) and don't grip the tool
Instructions Pose 2 Bring the tool in a straight hori: After positioning the tool keep Important: use the robot's ow Note: Always move the robot when making pose changes.	contal position facing to the right or i your hands away from the robot and n interface to move the robot; MIRA by the robot arm (above the force/to	left (as shown in the illustration above). I tap on "Measure". I hand-guiding is disabled. Exque sensor) and don't grip the tool
Instructions Pose 2 Bring the tool is a straight hori. After positioning the tool, keep Important: use the robot's own Note: Always move the robot when making pose changes. Measure	contal position facing to the right or your hands away from the robot and interface to move the robot; MIRA by the robot arm (above the force/to	eff (as shown in the illustration above). I tap on "Measure". I hand-guiding is disabled. xrque sensor) and don't grip the tool
Instructions Pose 2 Bring the tool is a straight horiz After positioning the tool keep Important: use the robot's ow Note: Always move the robot's when making pose changes. Measure	rontal position facing to the right or i your hands away from the robot and interface to move the robot; MIRA by the robot arm (above the force/rc	eff (as them in the illustration above), I tap on "Measure". I hand-guiding is disabled. xrque sensor) and don't grip the tool
Instructions Pose 2 Bring the tool is a straight horiz After positioning the tool keep Important: use the robot's ow Note: Always move the robot's when making pose changes Measure	contal position facing to the right or is your hands away from the robot and interface to move the robot; MIRA by the robot arm (above the force/rc	eff (ng shown in the illustration above). It is on "Neasure". I hand-guiding is disabled. Xrque sensor) and don't grip the tool
Instructions Pose 2 Bring the tool in a straight horiz Affer positioning tool keep Important: use the robot's ow Note: Always move the robot when making pose changes Measure	tornal a dollar faring a the higher of your lands away from the robot and interface to move the robot. MIRA by the robot arm (above the force/ro	eff (na shown in the illustration above). In and guiding is disabled. Xrque sensor) and don't grip the tool
Instructions Pose 2 Bring the tool is a stright hort After positioning the tool keep Important: use the robot's ow Note: Always move the robot when making pose changes.	total a load on faving on the spike of your lands away from the robot and initerface to move the robot. MIRA by the robot arm (above the force/to	eff (na shown in the illustration above). It is on "Nearus". It hand-guiding is disabled.
Instructions Pose 2 Bring the tool is a stright hori After positioning the tool keep Important: use the robot's ow Note: Always move the robot when making pose changes.	total al location fairing to the right of + your hands away from the robot and interface to move the robot MIRA by the robot arm (above the force/to	eff (na shown in the illustration above). It is on 'Neaure', I hand-guiding is disabled.
Instructions Pose 2 Bring the tool is a stright hori: After positioning the tool keep important: use the robot's ow Note: Always move the robot when making pose changes.	tontial position facing to the right of A your hands away from the robust and interface to move the robust MIRA by the robust arm (above the force/to	eff (na shown in the illustration above). If you on Weasure, if you on the other of the other of the other of the other of the other
Instructions Pose 2 Bring the tool is a stright horizont After positioning the tool keep important: use the robot's ow Note: Always move the robot when making pose changes.	tontal position facing to the right of A your hands away from the robust and interface to move the robust MIRA by the robust arm (above the force/to	eff (nas thown in the illustration above). If you on Weasure, If and guiding is disabled.

? Proceed with the next four poses by following the instructions on each screen.

Tool measurement process X	Tool measurement process X
Measurement Process - Pose 3/6	Measurement Process - Pose 4/6
Instructions Pose 3 Rotate the tool 90° clockwise (as shown in the illustration above). After positioning the tool, keep your hands away from the robot and tap on "Measure". Important: use the robot's own interface to move the robot; MIRAI hand-guiding is disabled.	Instructions Pose 4 Rotate the tool 90° clockwise again (as shown in the illustration above). After positioning the tool, keep your hands away from the robot and tap on "Measure". Important: use the robot's own interface to move the robot; MIRAI hand-guiding is disabled.
Note: Always move the robot by the robot arm (above the force/torque sensor) and don't grip the tool when making pose changes.	Note: Always move the robot by the robot arm (above the force/torque sensor) and don't grip the tool when making pose changes.
← Back Next pose →	← Back

Tool measurement process X	Tool measurement process X
Measurement Process - Pose 5/6	Measurement Process - Pose 6/6
Instructions Pose 5 Rotate the tool 90° clockwise again (as shown in the illustration above). After positioning the tool, keep your hands away from the robot and tap on "Measure". Important: use the robot's own interface to move the robot; MIRAI hand-guiding is disabled.	Instructions Pose 6 Bring the tool pointing straight upwards (as shown in the illustration above). After positioning the tool, keep your hands away from the robot and tap on "Measure". Important: use the robot's own interface to move the robot; MIRAI hand-guiding is disabled.
Note: Always move the robot by the robot arm (above the force/torque sensor) and don't grip the tool when making pose changes.	Note: Always move the robot by the robot arm (above the force/torque sensor) and don't grip the tool when making pose changes.
Measure	Measure
\leftarrow Back	← Back

⁽⁸⁾ After you have measured all six poses, tap **Finish**. The CoG estimates for your newly created tool will appear on the main screen.

■ MIRAI Tool o	onfiguration				
Tool Mass	& Center	of Grav	ity (CoG	3)	
Tools Selection Set up a new tool or o	hoose one you like	to edit.			
Tool Name	Mass	CoG CX	CoG CY	CoG CZ	
gripper	0.09 kg	0.03 mm	-0.28 mm	6.79 mm	Edit 🗍
test	5.00 kg	2.00 mm	2.00 mm	2.00 mm	Edit 📋
		Set up n	ew tool +		
← Back					

3.2.1.1 Delete a tool

You can only delete tools not used in a skill. To delete a tool, tap next to the Edit button. A pop-up warning will be displayed. Tap **I have read the warning and want to delete the tool**.

Mass & Center of Gravity (CoG) tools selection Tool Mass & CoG CX CoG CY CoG CZ priper 0.09 kg 0.03 mm 0.28 mm 6.79 mm Edit 11 tool Name 0.09 kg 0.03 mm 0.28 mm Edit 11 total mark Ettics new tool 4		configuration					
tools statection Dart par new tool or of booser one-you live to wolk: Tool Name Mass CoG CX CoG CY CoG CZ pripper 0.09 kg 0.03 mm 0.28 mm 6.79 mm Edit 11 est 5.00 kg 2.00 mm 2.00 mm Edit 11 Sett con new tool 4	Tool Mass	& Center	of Gravi	ity (CoG	i)		
Mass CoG CX CoG CY CoG CZ p/pper 0.09 kg 0.00 mm 0.28 mm 6.79 mm Edit 11 test 5.00 kg 2.00 mm 2.00 mm Edit 11 Set top new tool +	Tools Selection Set up a new tool or o	choose one you like	to edit.				
pripper 0.09 kg 0.03 mm 0.28 mm 6.79 mm Edit () est 5.00 kg 2.00 mm 2.00 mm Edit () Set up new tool +	Tool Name	Mass	CoG CX	CoG CY	CoG CZ		
est 5.00 kg 2.00 mm 2.00 mm 2.00 mm Edit 👔	gripper	0.09 kg	0.03 mm	-0.28 mm	6.79 mm	Edit	Î
Set up new tool +	test	5.00 kg	2.00 mm	2.00 mm	2.00 mm	Edit	Î
			Set up n	rw tool +			
	← Back						
← Back							

Tool Mass	& Center	of Grav	ity (CoG			
Tools Selection Set up a new tool or o	hoose one you like	to edit.				
Tool Name	Mass	CoG CX	CoG CY	CoG CZ		
Bubber	0.02 mg	0.00 1111	V.LO HEH	V.7211111		
test Wa	rning!					
test2 Once actio	this tool is delet n can not be und	ed, it cannol Ione.	be used to se	et up a skill. Thi	°] f	
test3						
test44	I have	read the wa	ming and wa	nt to delete the	tool	
test444				Ca		
saeed	2.05 kg	5.00 mm	13.00 mm	75.00 mm	Edit	
Rotation tests	0.13 kg	0.06 mm	0.40 mm	125.00 mm	Edit	
test tool	-0.00 kg	-6307.59 mm	84099.63 mm	2625.45 mm	Edit	
		Set up n	ew tool +			ſ

4 The Training Loop - Recording Episodes

When you start recording episodes for your skill, you enter the training loop. Here you proceed with successively recording episodes until you have collected enough good data for a first version of your skill.

4.1 Training without a F/T Sensor

4.1.1 Training a Positioning Skill

- 4.1.1.1 Before Recording an Episode
- (1) With the newly created skill in the home screen, tap on the 'Open' button on the right-hand side of the new skill to enter the "Details" screen.

	w		20
Local skills	All skills	Add new s	kill +
Last updated: 26.09.2023	3 - 16:27		
Test Skill Motion		Open	
Modified: 26.09.2023 - 04.02 Cloud episodes 5 Local episo	Skill versions 01 des 5		
Test Skill Position	ning		
Positioning skill Modified: 26.09.2023 - 03.58	Skill versions 01	Open	;
Cloud episodes 5 Local episo	odes 5		
Cloud episodes 5 Local episo	ur and 15 minutes remaining		
Cloud episodes 5 Local episo	ides 5 or and 15 minutes remaining		
Cloud training in progress 1 ho	or and 15 minutes remaining		
Cloud privates 5 Local representation	ur and 15 minutes remaining		
Cloud reliades 5 Local reliades	ur and 15 minutes remaining		
Chud rpinote S Local rpinote S	or and 15 mmutes remaining		
Churd reports S	der 5		
Chead reports S	der 5		

The 'Details' screen contains information about the skill and the steps to create it.



2 In the 'Details' screen tap on the "Record episodes" button to enter the training loop.

 Test Skill Positioning 5 			
Details Episodes Sk	III versions		
Skill Information			Ý
	General:		
	Skill-ID:		
	152_16_202309	926145257	
	Skill type:		Robot:
Reference image Camera 1	Positioning skill		UR5e
Reference image camera i	Axis translation Translations (X	NS: V 7)	Axis rotations:
		/	(((())))
	Camera:		
	Number of cameras:		
	Dual camera		
Reference image Camera 2	Gain Camera 1: 1		Exposure Camera 1: 5000
	Gain Camera 2: 1		Exposure Camera 2: 5000
	Tool		
	Tool name: Tool Test		
	TCP Displacement:		
	X: 8 mm	Y: 0 mm	Z: 5 mm
	RX: 4.0 rad	RY: 0.0 rad	RZ: 0.0 rad
Collect data		_	
Record enough episodes to cover all the relevant			Record episodes
conditions of your task.			

3 Tap on to add a text label. You can tag the episodes or series of episodes with meaningful names that best describe the condition, environment, or the object. This will help you plan and keep track of your recording steps. Please see section 4.6 Adding Tags or Text Labels for Episodes for more details.

← Skill Training Positionin	g skill	Skill: Sensorless Testskill (0)		
$\label{eq:restricted} \begin{tabular}{c} \label{eq:restricted} \\ \end{tabular} \\ tabula$				
	● Start recording			
min. 00:00		max. 03:00		
	(† 165)			
ീ	÷	0		
Recording assistant	Reference position	Help center		

4.1.1.2 Recording Episodes Using the Recording Assistant

The Recording Assistant enables you to train robust positioning skills with less effort and without using a Force/Torque sensor. It assists with automating the recording of an episode by autonomously moving the robot within a predetermined area.
This feature can only be used for training positioning skills (new, old, with or without rotations; this cannot be used when training motion skills or multi-target positioning skills).

- 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 (see section 3, 'Create a new skill').
- Tap 'Recording assistant' at the bottom left corner.



Setting up the Recording Assistant

• On the lower half of the screen which appears after, tap the 'Start setup' button to proceed.

Skill Training Target frame review	Skill: Skilname with a maximum of 35 cha. (000)
Before recording, place the robot at th	e exact target position.
Recording assistant Recording assistant an help automate the recording of a robot within a defined area.	n episode by autonomously moving the
CLP	n Help center

- Setting up the Recording Assistant feature involves three major steps:
 - Step 1: Choose 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). But 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.
 - * Select 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.
 - * Then tap 'Next'.

- Step 2: Shape the handover region:
 - * Move the robot in at least 3 poses 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 'Next'.
 - * Deleting positions:
 - Below the 'Save position' button, the 'Delete all' button will indicate how many poses you have saved so far.
 - If you are not satisfied with what you have saved, you may choose to 'Delete all' and start over.
 - $\cdot\,$ When the poses you have determined do not span a polygon, you will need to delete all the poses and start over.



- Step 3: Adjust the motion settings (optional):
 - * Change MIRAI's default motion values to further limit the motions of the recording assistant near the target or to better control its rotational movements
 - * Amplitude of random rotations:
 - Only available for skills with rotations enabled!
 - Recording Assistant performs **many small**, **random tool orientation changes** throughout the recording. This section allows you to configure the amplitude of those random rotations in each axis enabled in skill creation.
 - Enter a value **between 0° and 15°** to configure the maximum amplitude per tool axis.

Skill Training Target frame r	eview	Skills Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion s	ettings (optional)	
Limit the motions of the recordin movements.	ig assistant near the target and f	urther control its rotational
Amplitude of random rotations	0	
RX (0 ° - 15 °)	RY (0 * - 15 *)	RZ (0 * - 15 *)
5	5	5
Obstacle-free space near the ta Orientation	rget • z-axis	
Size 📵		
Beyond the target (mm)	Around the ta	irget (mm)
24	24	
e Back		Finish
جي Recording assistant	-> Reference position	(?) Help center

i Note

In addition, even with 0° random rotations, Recording Assistant **will always rotate the tool as much as necessary** to interpolate from the orientation of the target pose to that of the poses that shape the handover region. Thus, the more these orientations differ, the stronger the overall orientation change during recording, independent of this setting.

- * Orientation of additional recording volume:
 - In addition to the volume between the target and poses that shape the handover region, recording assistant will visit a small volume "beyond" and "around" each MIRAI target pose. The purpose of this is to record data on recovering from overshooting and imprecision.
 - This additional recording volume has the shape of a cylinder, extending from the target tool pose outwards "beyond" the target along a chosen axis (in tool TCP coordinates, including the TCP displacement inputted when creating the MIRAI skill).



 $\cdot\,$ The axis defining the point "beyond" the target and thus the orientation of the cylindrical shape is configurable.



• Choose the axis that is closest to the major direction of motion of the skill near the target—for example, the z-axis for a skill that moves down towards an object on a table.

Skill Training Target frame rev	iew s	kill: Skillname with a maximum of 35 cha. (500)
Step 3/3: Adjust motion set Limit the motions of the recording movements.	ttings (optional) assistant near the target and fur	ther control its rotational
Amplitude of random rotations	•	
RX (0 * - 15 *)	RY (0 * - 15 *)	RZ (0 * - 15 *)
	2	<u>.</u>
Obstacle-free space near the targ Orientation	et	
🔿 x-axis 🔿 y-axis	z-axis	
Size 1		
Beyond the target (mm)	Around the targ	et (mm)
← Back		Finish
Recording assistant	->> Reference position	(?) Help center

- * Size of additional recording volume:
 - Choose the distance from the target tool pose outwards "beyond" the target along the chosen axis. The radius of the cylinder is also configurable, and defines how far "around" the target recording assistant will move.



Skill Training Target frame r	eview	SHR: Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion s Limit the motions of the recordin movements. Amplitude of random rotations RX (0 * - 15 *)	ettings (optional) Ig assistant near the target and 1 RY (0 * - 15 *)	further control its rotational RZ (0 * – 15 *)
5	5	5
Obstacle-free space near the ta Orientation x-axis y-axis	erget	
Size Beyond the target (mm) 24	Around the ta	arget (mm)
← Back		Finish
ে ? Recording assistant		(7) Help center

- Tap on 'Finish' when you are satisfied with the motion settings.

Skill Training Target frame	review	Skills Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion	settings (optional)	
Limit the motions of the recordi	nn assistant near the tarnet and f	urther control its rotational
movements.	ng assistant near the target and i	
Amplitude of random rotations	0	
RX (0 ° - 15 °)	RY (0 * - 15 *)	RZ (0 ° - 15 °)
5	5	5
Obstacle-free space near the ta Orientation • • x-axis • y-axis	s e z-axis	
Size 🚺		
Beyond the target (mm)	Around the ta	arget (mm)
24	24	
← Back		Finish
Recording assistant		(?) Help center

• Once you are done with the steps above, the Recording Assistant setup is ready to use. You can choose to move on with recording an episode by tapping the '**Close**' button. Otherwise, if you want to modify your setup, click on the 'Adjust setup' button instead.

Skill Training Target frame r	eview	Skill: Skilname with a maximum of 35 cha. (000)
Before recording, plac	ce the robot at the exa	act target position.
Recording assistant	successfully set up for this sess	ion. It will appear automatically
wherever a new recording is star	teu.	
← Adjust basic setup		Close
رچ Recording assistant		(?) Help center

Recording Episodes with the Recording Assistant

Please note the safety reminders below before using the Recording Assistant:

Safety precautions

- ☑ Keep a close watch on the robot's motion. Interrupt the process if necessary.
- ☑ Make sure that the volume outlined between the handover region, target pose, and additional recording volume is **free of obstructions**.
- 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, use the feature **cautiously and slowly**, and observe if the robot's motion aligns with your preference.
- Start with a slower setting (i.e., turtle speed), and then consider faster speeds (i.e., gradually increasing towards rabbit speed) when you feel that you are comfortable with the motion taking place.
- Place the robot at a desired target position when you are ready to record, then tap 'Start recording' to proceed.



• At the bottom of the screen, the speed slider allows you to adjust how slow or fast the scanning motion should be. We recommend that you start with the slowest (default) setting (i.e., the turtle icon on the leftmost side represents the slowest setting, while the rabbit icon on the rightmost side represents the fastest setting). The Recording Assistant will not begin until you have selected your speed preference.

i Note

If the robot is too far away from the defined handover region, move the robot to the appropriate area and restart the recording.



• You are notified when the Recording Assistant has finished (at the bottom of the screen); however, the recording of the episode will not be automatically terminated. You must select 'Stop recording'.



4.1.1.3 Saving Episodes

1) If the episode recorded is optimal, select 'Save' to save it; if not, choose 'Discard' to delete it.

Note

The **episode counter** (on the top right corner of the screen, in brackets) shows the number of good recordings collected so far.

← Skill Training Positioning skill	Skill: Sensorless Testskill (0)
Save or discard current episode?	
🖉 Save	S Discard
6100	

2 **Choose a different target position** and tap on 'Start recording' to proceed with the next episode. The number of successfully recorded episodes is indicated on the top-right corner.

← Skill Trainin	g Positioning skill	Skill: Sensorless Testskill (0)
color_vision_1 Place the recording	robot at the exact target pos	The second secon
	• Start recording	
min. 00:00		max. 03:00
	(2)	
್	->	0
Recording assistar	nt Reference position	Help center

- ³ Record a minimum of 5-10 episodes. Ensure that **all relevant variances are captured** in order to derive a meaningful and functional skill. Capture relevant variances in different episodes to expose the skill to the spectrum of changes and variances that are expected to be seen in the setup during execution.
- 4 After recording the desired number of episodes, **leave the training loop through the home button** (top left corner) which opens the 'Skills in Training' home screen (see section 5.3 'MIRAI Cloud Training and Skill Versions'.)

4.2 Training with a F/T Sensor

4.2.1 Training a Positioning Skill

4.2.1.1 Before Recording an Episode

A Warning

During the training process, robot movement can be controlled by hand-guiding. If **hand-guiding is activated**, the robot can be moved in any direction. Please pay attention to not squeeze your free hand and fingers by accident or shear any body parts. Be especially careful when the robot is handling workpieces with sharp edges or pointed contours.

(1) With the newly created skill in the home screen, tap on the 'Open' button on the right-hand side of the new skill to enter the "Details" screen.



The 'Details' screen contains information about the skill and the steps to create it.



2 In the 'Details' screen tap on the "Record episodes" button to enter the training loop.

Datalla Falandar (1)			
Details Episodes Si	kill versions		
Skill Information			Ŷ
	General:		
	Skill-ID:	026145257	
	Skill type:	1920143237	Robot:
	Positioning ski	11	UR5e
Reference image Camera 1	Axis translation Translations ()	ns: (, Y, Z)	Axis rotations: (X, Y, Z)
	Camera:		
	Number of car Dual camera	neras:	
Reference image Camera 2	Gain Camera 1 1	:	Exposure Camera 1: 5000
	Gain Camera 2 1	E	Exposure Camera 2: 5000
	Tool		
	Tool name: Tool Test		
	TCP Displacer	nent:	
	X: 8 mm	Y: 0 mm	Z: 5 mm
	RX: 4.0 rad	RY: 0.0 rad	RZ: 0.0 rad
Collect data		_	
Record enough episodes to cov	ver all the relevant	ſ	Record episodes

(3) In the next step, please ensure that the robot is in the correct target position, either by sending the robot automatically to the predefined reference position ('Send to reference position') or manually guiding it to a user defined starting point ('Manual positioning').

← Skill Training Positioning	Skill: test positioning 5 (0)	Skill Training Positioning	Skill: test positioning 5 (0)
Skill Training I Positioning Image: Send to reference position	Bill: test positioning 5 (ø)	Skill Training Positioning • Skill Training Positioning • Send to reference position • Warning! • Pressing this button will cause: onding will get in the way of the reference position. • Cancel	Bkill: test positioning 5 (0)
Calibration Reference position G		Calibration Reference position	Ξ ? Guiding sensitivity Help center

(4) Remove hands from robot to calibrate the F/T sensor and tap on 'Calibrate F/T sensor' to proceed.



i Note

Before beginning the recording, read the instructions carefully.

- 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).
- Guide the tool to its target position, before recording an episode.

<image/> <section-header><section-header><section-header><list-item><list-item><list-item></list-item></list-item></list-item></section-header></section-header></section-header>	Positioning skills - How to train
Before according: Make sure there is no obstruction for the direct path from the starting position (handover point) to the target position of the direct path from the starting position (handover add variance) in target (balance) position (bandover add variance) in target (balance) position (bandover add variance) in target position (bandover add variance) in target position (bandover add variance) are directly add variance) are directly add variance) are directly add variance) and the arget adding the entire episode Mave the robot in a crisa-crossing sprial motion over the target and around it Send most of the time near the target Ordinue your sprial motion at an increasing distance away from the target, all the way back to the handover point. Near the handover point. Resp the target and the end effector in view at all times For skills with rotations: repeat the sprial motion at various orientations of the tool.	
Add variances in: target [object] position/orientation; color and shape of the target object: fieldie object in the origoer, background, lighting conditions Guide the robot to the exact (final) target position Daring recording: Do not move the target during the entire episode Move the robot in a crise-crossing spiral motion over the target and around it Spend most of the time near the target Oratine your spiral motion at an increasing distance away from the target, all the way acks to the handware point Near the robot point of the orient at an increasing distance away from the target, all the way acks to the handware point Near the robot	Before recording: • Make sure there is no obstruction for the direct path from the starting position (handover point) to the target position
Guide the robot to the exact (final) target position During recording: O not move the target during the entire episode Move the robot in a criss-crossing spiral motion over the target and around it Spend most of the time near the target Oratinue your spiral motion at an increasing distance away from the target, all the way acks to the final nove priorit Keep the target and the end effector in view at all times For skills with rotations: repeat the spiral motion at various orientations of the tool	 Add variances in: target [object] position/orientation; color and shape of the target object; flexible object in the priper; background: lighting conditions
During recording: • Do not move the target during the entire episode • Move the robot in a criss-crossing spiral motion over the target and around it • Spend most of the time near the target • Continue your spiral motion at an increasing distance away from the target, all the way back to the thandware point • Keep the target and the end effector in view at all times • For skills with rotations: repeat the spiral motion at various orientations of the tool	Guide the robot to the exact (final) target position
Do not move the target during the entire episode Move the robot in a criss-crossing spiral motion over the target and around it Spend most of the time near the target. Ordniture your spiral motion at an increasing distance away from the target, all the way tasks to the handware point Keep the target and the end effector in view at all times For skills with rotations: repeat the spiral motion at various orientations of the tool	During recording:
Move the robot in a criss-crossing spiral motion over the target and around it Spend most of the time near the target Continue your spiral motion at an increasing distance away from the target, all the way back to the thandware point Keep the target and the end effector in view at all times For skills with rotations repeat the spiral motion at various orientations of the tool	Do not move the target during the entire episode
Spend most of the time near the target Continue your spiral motion at an increasing distance away from the target, all the way back to the thandwore point Keep the target and the end effector in view at all times For skills with rotations repeat the spiral motion at various orientations of the tool	Move the robot in a criss-crossing spiral motion over the target and around it
Ordinue your spiral motion at an increasing distance away from the target, all the way back to the handover point. Veep the target and the end effector in view at all times For skills with rotations repeat the spiral motion at various orientations of the tool	Spend most of the time near the target
Keep the target and the end effector in view at all times For skills with rotations: repeat the spiral motion at various orientations of the tool	 Continue your spiral motion at an increasing distance away from the target, all the way back to the handover point
For skills with rotations: repeat the spiral motion at various orientations of the tool	Keep the target and the end effector in view at all times
	For skills with rotations: repeat the spiral motion at various orientations of the tool
Got it	Got it

- 5 You can adjust the guiding sensitivity by tapping on the Guiding Sensitivity button in the bottom bar. Please see section 4.4 'Guiding Sensitivity' for more details.
- 6 Tap on to add a text label. You can tag the episodes or series of episodes with meaningful names that best describe the condition, environment, or the object. This will help you plan and keep track of your recording steps. Please see section 4.6 'Adding Tags or Text Labels for Episodes' for more details.
- To start the first episode, guide the robot TCP to its target position and tap on the 'Start Recording' button. 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.



4.2.1.2 Recording Episodes Using the Recording Assistant

The Recording Assistant enables you to train robust positioning skills with less effort. It assists with automating the recording of an episode by autonomously moving the robot within a predetermined area.

This feature can only be used for training positioning skills (new, old, with or without rotations; this cannot be used when training motion skills or multi-target positioning skills). It is currently released as a 'beta' version.

- 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 (see section 3, 'Create a new skill').
- Tap 'Recording assistant' at the bottom right corner.



Setting up the Recording Assistant

• On the lower half of the screen which appears after, tap the 'Start setup' button to proceed.

Skill Training Target frame r	eview sk	IR Skiliname with a maximum of 35 cha. (000)
Before recording, plac	the robot at the exact	target position.
Recording assistant		
Recording assistant can help aut robot within a defined area.	omate the recording of an episode t	ay autonomously moving the
		Start setup
്	Ð	0
Recording assistant	Reference position	meip center

- Setting up the Recording Assistant feature involves three major steps:
 - Step 1: Choose 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). But 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.

- * Select 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.
- * Then tap 'Next'.

Skill Training Target frame review	Skills: Skillname with a maximum of 35 cha. (000)
Step 1/2: Choose handover behavior	
Consider your application workspace: Where will the And: Does this stay fixed from execution to execut For most applications, the handover point will stay for certain tasks such as depalletizing, it can be u	he robot tool be when MIRAI skill takes control? tion? y the same for every execution (default setting). But selful to start each skill execution at a new location
that depends on the position of the intended targe	n.
 Handover point stays fixed (default) 	 Handover point moves with target
Every execution of this skill starts from roughly the same position in the workspace.	The skill will be executed at different positions in the workspace, depending on the position of the intended target object.
- Back	Next ->
Recording assistant Reference	e position Help center

- Step 2: Shape the handover region:
 - * Move the robot in at least 3 poses 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 'Next'.
 - * Deleting positions:
 - Below the 'Save position' button, the 'Delete all' button will indicate how many poses you have saved so far.
 - If you are not satisfied with what you have saved, you may choose to 'Delete all' and start over.
 - When the poses you have determined do not span a polygon, you will need to delete all the poses and start over.



- Step 3: Adjust the motion settings (optional):
 - * Change MIRAI's default motion values to further limit the motions of the recording assistant near the target or to better control its rotational movements
 - * Amplitude of random rotations:
 - Only available for skills with rotations enabled!
 - Recording Assistant performs **many small**, **random tool orientation changes** throughout the recording. This section allows you to configure the amplitude of those random rotations in each axis enabled in skill creation.
 - Enter a value **between 0° and 15°** to configure the maximum amplitude per tool axis.

Skill Training Target frame	eview	Skills Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion	settings (optional)	
Limit the motions of the recordin movements.	ng assistant near the target and fu	rther control its rotational
Amplitude of random rotations	0	
RX (0 * - 15 *)	RY (0 * - 15 *)	RZ (0 * - 15 *)
5	5	5
Obstacle-free space near the ta Orientation x-axis y-axis y-axis	rget	
Size 🚺		
Beyond the target (mm)	Around the tar	get (mm)
24	24	
← Back		Finish
جج Recording assistant	-> Reference position	(?) Help center

i Note

In addition, even with 0° random rotations, Recording Assistant **will always rotate the tool as much as necessary** to interpolate from the orientation of the target pose to that of the poses that shape the handover region. Thus, the more these orientations differ, the stronger the overall orientation change during recording, independent of this setting.

- * Orientation of additional recording volume:
 - In addition to the volume between the target and poses that shape the handover region, recording assistant will visit a small volume "beyond" and "around" each MIRAI target pose. The purpose of this is to record data on recovering from overshooting and imprecision.
 - This additional recording volume has the shape of a cylinder, extending from the target tool pose outwards "beyond" the target along a chosen axis (in tool TCP coordinates, including the TCP displacement inputted when creating the MIRAI skill).



 $\cdot\,$ The axis defining the point "beyond" the target and thus the orientation of the cylindrical shape is configurable.



• Choose the axis that is closest to the major direction of motion of the skill near the target—for example, the z-axis for a skill that moves down towards an object on a table.

Skill Training Target frame rev	iew s	killt: Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion se Limit the motions of the recording movements.	ttings (optional) assistant near the target and fur	ther control its rotational
Amplitude of random rotations	•	
RX (0 * - 15 *) 5	RY (0 * - 15 *) 5	RZ (0 * - 15 *) 5
Obstacle-free space near the targ Orientation	et	
Beyond the target (mm)	Around the targ	jet (mm)
24	24	
E Back		Finish
Recording assistant	->> Reference position	(?) Help center

- * Size of additional recording volume:
 - Choose the distance from the target tool pose outwards "beyond" the target along the chosen axis. The radius of the cylinder is also configurable, and defines how far "around" the target recording assistant will move.



Skill Training Target frame r	eview	SHR: Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion s Limit the motions of the recordin movements. Amplitude of random rotations RX (0 * - 15 *)	ettings (optional) Ig assistant near the target and f RY (0 * - 15 *)	further control its rotational RZ (0 * – 15 *)
5	5	5
Obstacle-free space near the ta Orientation	rget • z-axis	
Size Beyond the target (mm) 24	Around the ta	arget (mm)
← Back		Finish
ে ট Recording assistant	->> Reference position	(?) Help center

- Tap on 'Finish' when you are satisfied with the motion settings.

Skill Training Target frame	review	Skills Skillname with a maximum of 35 cha. (000)
Step 3/3: Adjust motion	settings (optional)	
Limit the motions of the recordi	nn assistant near the tarnet and f	urther control its rotational
movements.	ng assistant near the target and i	
Amplitude of random rotations	0	
RX (0 ° - 15 °)	RY (0 * - 15 *)	RZ (0 ° - 15 °)
5	5	5
Obstacle-free space near the ta Orientation • • x-axis • y-axis	s vraxis	
Size 🚺		
Beyond the target (mm)	Around the ta	arget (mm)
24	24	
← Back		Finish
Recording assistant		(?) Help center

• Once you are done with the steps above, the Recording Assistant setup is ready to use. You can choose to move on with recording an episode by tapping the '**Close**' button. Otherwise, if you want to modify your setup, click on the 'Adjust setup' button instead.

Skill Training Target frame re	view	Stell: Skilname with a maximum of 35 cha. (000)
Before recording, plac	e the robot at the exa	ict target position.
Recording assistant		
Recording assistant has been a whenever a new recording is start	successfully set up for this sess ted.	ion. It will appear automatically
← Adjust basic setup		Close
අ	Ð	0
Recording assistant	Reference position	neip center

Recording Episodes with the Recording Assistant

Please note the safety reminders below before using the Recording Assistant:

Safety precautions

- ☑ Keep a **close watch on the robot's motion**. Interrupt the process if necessary.
- ☑ Make sure that the volume outlined between the handover region, target pose, and additional recording volume is **free of obstructions**.
- 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, use the feature **cautiously and slowly**, and observe if the robot's motion aligns with your preference.
- Start with a slower setting (i.e., turtle speed), and then consider faster speeds (i.e., gradually increasing towards rabbit speed) when you feel that you are comfortable with the motion taking place.
- Place the robot at a desired target position when you are ready to record, then tap 'Start recording' to proceed.



• At the bottom of the screen, the speed slider allows you to adjust how slow or fast the scanning motion should be. We recommend that you start with the slowest (default) setting (i.e., the turtle icon on the leftmost side represents the slowest setting, while the rabbit icon on the rightmost side represents the fastest setting). The Recording Assistant will not begin until you have selected your speed preference.

i Note

If the robot is too far away from the defined handover region, move the robot to the appropriate area and restart the recording.



• You are notified when the Recording Assistant has finished (at the bottom of the screen); however, the recording of the episode will not be automatically terminated. You must select 'Stop recording'.



4.2.1.3 Recording Episodes Using Manual Recording

• Move the robot in a spiral motion away from the target and scan all the relevant points in the space surrounding it that the robot might encounter during the skill execution (see the image below), going all the way back to the starting point or the handover point, i.e., the point where MIRAI will take control from the previous robot program step.

For skills with no rotations enabled:

The goal is to visit all kinds of poses relative to the object that the robot might encounter during the execution of the skill. Imagine that you are "scanning" the object from various perspectives.

Recommend strategy: Begin with a gentle motion outward from the target pose, span all the possible relevant positions in space the robot may encounter during the real skill execution.

For skills with rotations enabled:

The goal here is to not only visit all the possible relevant points in space **but also include all possible orientations of the tool at each point**. Therefore, one should combine rotating the tool while spanning the whole relevant space.

Recommend strategy: Begin a gentle motion outward from the target pose, scan all the possible relevant positions in space the robot may encounter during the real skill execution while constantly rotating the tool. Make sure to show MIRAI the target from all points of view from different angles.

🗘 Tip:

Spend most of the recording time in a close neighborhood to the target.

- During recording, if you **let go of the robot**, it will move back to the target position (and in the target pose) via the shortest direct path. This "Rubber-banding"-practice makes it easier to keep the recordings focused on the target position. It also provides a preview of the final trajectory and direction the trained skill will perform from a given starting pose.
- Make sure there is no obstruction in the direct path from the intended starting point to the target.
- Please keep in mind that **at least part of the target must remain visible in the camera view** during the whole episode. Ensure the end of the tool center point is in view as well.
- Tap on 'Stop Recording' once the task is done. The counter gives you an indication of the total time recorded. The recordings are usually shorter; the maximum limit for recording is 3 minutes.



• Discard the episode 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 (for example, the ring light was turned off).
- The gripper or the target object was not part of the camera feed.

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!**

4.2.1.4 Training Tips

To achieve good results (a MIRAI skill that is effective and robust in handling dynamic changes and variances within the setup), it is important to pay attention to how to train the robot and capture this through the camera(s) across various recordings. The initial episodes you record will teach MIRAI to find

the target position. Subsequent episodes will teach MIRAI how to find the target while handling variances in the target, as well as variances in the environment.

♀ Tip:

It is helpful to imagine that everything the systems 'sees', i.e., captured in the recorded episodes and rated to be used, will impact the trained behavior, for the better or the worse.

Following is an overview of training tips for demonstrating and recording episodes:

- **Ensure start frames are consistent:** The robot tool needs to be precisely positioned at the target before every episode.
- **Hand placement:** Place your hand just below the Force/Torque sensor along the robot arm. An episode will fail if your hand falls into the field of view of the cameras be very mindful of this while rotating!
 - Holding the wrist near the F/T sensor ensures that even tiny motions from the tip of the tool/gripper are properly captured in the training. Reaching from higher will be more difficult to steer and may result in more jerky or unpredictable pathing.
- Train 5-10 good episodes and use them to create your first skill version.
 - You don't want to record too many episodes before sending them to the Micropsi cloud server; only train 5-10 episodes at a time to create a new version of your skill.
- **Each episode should include some form of variation** for MIRAI to learn from MIRAI does not learn from being shown the same thing twice. The trained skill will be more robust to variances in production if the full variety of possible situations is demonstrated in this recording session. Consider the sources of variance in your application (for more details see section 4.3 'Sources of Variances').
- Use the 40, 30, 20, 10 % Zone Rule:
 - Allocate episode training time by distance to the target.
 - Example: spend 40% of episode time up close (<5 mm), 30% near (<10 mm), 20% medium distance (<50 mm), 10% far away (>50 mm).
 - This is a good rule to keep in mind when recording your first 20 episodes, but less important as you record more episodes.



Figure 3: The 40, 30, 20, 10 % Zone Rule

- Move through all available axes of translation and rotation while recording episodes.
 - You need to teach MIRAI how to utilize all axes of movement while approaching the target.
 - Example: if it's a 6-axis skill, then you should move the robot tool through all 6 axes of motion; if it's a 4-axis skill, then you should move the robot through the 3 axes of translation while also rotating the 4th axes.
- **Do not move the robot tool into areas and orientations where it should never go** while recording episodes.
 - Showing MIRAI irrelevant areas is an inefficient use of training time it will not necessarily corrupt the skill, but it will not help it either.
- Show MIRAI "every seat in the stadium":
 - MIRAI needs to see every possible perspective.
 - MIRAI will learn to go to the target from whatever perspectives you show it during training.
 - Perspectives of the target that you do not show MIRAI will become like "blind spots" MIRAI will have trouble mapping its path to the target from these positions.
- Do not collide with the target during training.
 - This is likely to displace the target and the tool, creating bad data.
 - Delete any episode which shows the tool colliding with the target or fixture.
- **"Rubber-band" the robot** several times per episode: While recording an episode, if you let go of the robot (forces on the robot tool = 0), then MIRAI will return the robot tool to its start-frame position.
 - Doing this 2-3 times per episode is a good practice.
 - This shows MIRAI direct paths to the target, and it will help you show MIRAI more variance around the target per episode.
- Ideally, keep distracting objects out of view, such as hands or task-unrelated objects. (While it is possible to train reliable skills even in the presence of distractors, it comes at the cost of increased demonstration effort.)

• **Train for overshoots:** Show MIRAI what it looks like to overshoot the target. For example, what it looks like to move past the target, above the target, below the target, to the side of the target, or around the corner from the target etc.



Example of Overshooting the Target

Figure 4: Overshooting the target

• Save backups of your MIRAI controller: It is good practice to occasionally create backups of your MIRAI controller – especially once you have developed your skill to a satisfactory level. In the event that your MIRAI controller gets damaged or destroyed, it is helpful to have a backup of your MIRAI controller so that it may be easily restored. Creating a backup requires a USB flash drive – see chapter 11 'Backup and Restore'.

4.2.1.5 Saving Episodes & Leaving the Training Loop

1 If the episode recorded is optimal, select 'Save' to save it; if not, choose 'Discard' to delete it (for tips on how to determine non-optimal recording, kindly refer to the last part of section 4.2.1.3 'Recording Episodes Using Manual Recording').

← Skill Training Positioning	Skill: test positioning 2 (0)
Save or discard current epi	sode?
Save	Discard
÷ 73	

i Note

The episode counter (on the top right corner of the screen, in brackets) shows the number of good recordings collected so far.

2 Calibrate the F/T sensor. This measurement is required after every episode to avoid drifting during guiding.



3 Choose a different starting position and tap on 'Start recording' to proceed with the next episode.



- A Record a minimum of 5-10 episodes. Ensure that **all relevant variances are captured** in order to derive a meaningful and functional skill. Capture relevant variances in different episodes to expose the skill to the spectrum of changes and variances that are expected to be seen in the setup during execution.
- (5) After recording the desired number of training the episodes, leave the training loop through the home button (top left corner) which opens the 'Skills in Training' home screen (see section 5.3 'MIRAI Cloud Training and Skill Versions'.)

4.2.2 Training a Multi-Target Positioning Skill

4.2.2.1 Check Skill Information before Recording

1. Access skill details: On the home screen, tap the **Open** button next to the skill to access the **Details** screen.

MIRAI • Skill Overview		MIRAI controller	ID: 694 🖒	
Local skills	All skills	Add new s	Add new skill +	
ast updated: 25.11.2024 - 1	1:54			
Test				
Modified: 25.11.2024 - Skill versions: 0	11:50	Open	:	
Cloud episodes: 1 Local episodes: 1				
fanue re21 pos -	rot			
Skill ID: 39529	. 101			
Modified: 22.11.2024 - ⁻ Skill versions: 0	11:22	Open	:	
Cloud episodes: 0 Local episodes: 0				

The **Details** screen (shown below) displays an image preview, information about the skill, and buttons to guide you through the skill creation steps.



2. Check the reference image preview(s):

- Ensure the target object(s) are in view.
- Ensure the endpoint of the tool center point (TCP) is in view.
- Ideally, the camera perspective is parallel to the robot tool, making sure that all or part of the object closest to the TCP is visible.
- Identify any non-task-related objects, such as hands or miscellaneous parts. While training with extraneous objects is possible, it may require more episodes.

4.2.2.2 Recording Episodes

Recording an episode for multi-target positioning skills involves two main steps: 1) demonstrating the target poses to MIRAI and 2) presenting the scene to MIRAI. This section describes the process.

A Warning

When using hand-guiding to control robot movement, keep your hands and fingers clear of pinch points and moving parts. Be especially cautious with sharp or pointed workpieces. Stay aware of your surroundings to prevent injury

Pre-recording: Set robot position and calibrate force/torque sensor

- 1. On the **Details** screen, tap **Record an episode** to enter the training loop.
- 2. Send the robot to the correct starting position:
 - To send the robot to a predefined reference position, tap Send to reference position.
 - To manually guide the robot to a starting point, select Manual positioning.
- 3. Calibrate the force/torque sensor (if used): Ensure you are not touching the robot (any force will affect calibration) and tap Calibrate Force/Torque sensor to proceed.



i Note

To improve accuracy, relocate 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 ensures MIRAI accurately judges distances to target objects. For details, refer to 3 Create a new skill.

Step 1: Define target poses for MIRAI In this step, you will save images of the end effector at each of its target locations, or "target poses." The following substeps will guide you through the process in the MIRAI Training App and provide tips.

1. Set the first target pose:

- Position the robot's end effector at the first target location.
- Tap **Save target pose** to confirm. A green "Pose saved successfully" message will appear, and the Delete buttons and Step 2 button will be activated.

• When defining subsequent target poses, ensure that they are as precise and consistent as

possible across episodes. The **camera grid** feature ^(IIII) (located at the top right corner of the camera view) can help with more accurate and easier positioning of the robot.



2. Repeat for additional targets:

- Move the robot's end effector to the next target position.
- Tap Save target pose to confirm.
- Continue this process until all target poses are saved.

3. Handle empty scenes:

- Use an empty scene without items to signal where the robot should wait for the scene to change. Save a target pose above the scene.
- Consistency in defining this target pose is important. Use the **Reference Position** feature (in the bottom navigation bar) to assist with this.

4. Define stopping conditions:

- Ensure there is a fixed visual cue or landmark in the scene to help MIRAI identify when to stop.
- You can also use the position-based end state to define stopping conditions.

5. Delete target poses:

• To improve skill accuracy, delete imprecise target poses. Use the buttons on the screen (*shown below left*) to delete all or single poses.
- *To delete all poses:* Tap **Delete all**. The number on this button indicates the number of saved target poses. When the confirmation prompt appears, tap **Yes, delete all target poses**.
- *To delete a single pose:* Tap **Delete last**, which deletes the last pose viewed. When the confirmation prompt appears, tap **Delete last target pose**.





Confirmation prompt: Delete all poses



Confirmation prompt: Delete last pose

6. Proceed to Step 2:

• When you are satisfied with the saved target poses, tap **Step 2** at the bottom right of the screen to proceed.

Step 2: Make recordings to train a multi-target skill

In this step, you will make the recordings ("episodes") to train your skill. The following substeps will guide you through the process in the MIRAI Training App and provide tips.

Before recording an episode, consider adjusting the guiding sensitivity and adding tags:

Adjust guiding sensitivity to your task: For example, reduce sensitivity for skills with rotations to achieve a smooth trajectory. To change sensitivity:

- **1** Tap **Guiding Sensitivity** in the bottom bar.
- 2 Tap Apply Settings and move the robot arm to check the sensitivity.

Add tags to organize episodes: Tags are labels that help you note specific variations, such as lighting, positions, or the person recording. They provide an overview of your recordings and help to identify gaps.

To add a text label, tap +Tags. For details, refer to 4.6 Adding Tags or Text Labels for Episodes.

When you are ready to record, follow these steps:

- 1. Record an episode:
 - Tap Start recording.
 - Move the robot in an upward spiraling motion to capture the entire scene, focusing on target objects if present.
 - You can record an episode for up to 3 minutes.
 - Once the task is done, tap Stop recording.



2. Recording strategies:

• For skills with no rotations enabled:

Goal: Aim to recreate all positions relative to the targets that the robot might move through during skill execution.

Strategy: Begin with a gentle motion outward from each target pose, moving the end effector across all positions that could occur during skill execution. Imagine that you are "scanning" the object from various perspectives.

• For skills with rotations enabled:

Goal: Aim to recreate all positions relative to the targets that the robot might move through during skill execution **and** to include all possible orientations of the tool at each point.

Strategy: Begin with a gentle motion outward from each target pose, moving the end effector across all relevant positions while constantly rotating the tool. Show MIRAI each target from different angles. Move objects around within episodes.

3. Create variations in your scene:

- Record scenes with relevant objects:
 - Start with many pickable objects in the scene. In subsequent episodes, vary and lessen the number of objects.
 - Move objects around between episodes to cover the full range of possible object positions. This can be done systematically (e.g., moving objects row-by-row on an imagined grid) or randomly (e.g., if object positions are determined by an upstream process component).
 - If the skill deals with varying appearances of objects, such as corrosion patterns or different colors and shapes, change the setup to cover a wide variety of appearances.
 - Change the lighting conditions.
- Record scenes with only non-relevant objects.
- Record at least one empty scene (i.e., with no relevant objects present).

4. Tips for succesful episodes:

- Spend most of the recording time close to each target.
- During recording, if you let go of the robot, it will move back to the closest target pose via the shortest direct path. This helps keep recordings focused and provides a preview of the final motion.
- Ensure at least part of the target remains visible in the camera view throughout the episode.

5. Discard the episode if:

- Your hand was in the camera view
- The target objects were accidentally moved during recording
- The lighting conditions were suboptimal or changed suddenly during recording, for example, if the ring light was turned off
- The target object was not in the camera view
- The robot reaches its joint limitations (singularity)

4.2.2.3 Saving episodes and leaving the training loop

If the episode recorded is optimal, tap Save. If not, tap Discard.



After saving an episode, you must **calibrate the force/torque sensor**. This is required to avoid drifting during guiding. Tap **Calibrate F/T sensor** when prompted or tap **Calibration** on the bottom bar.

Before recording your next episode, **set up a variation of your scene**. Then tap **Reference position** on the bottom bar to send the robot arm to its reference position.



Record **at least 5-10 episodes** with relevant variations to develop a functional skill. This ensures the skill can handle the expected changes during execution.

Use the **episode counter** in the top right corner of the screen to keep track of the episodes you have recorded. The number in brackets indicates the number of saved recordings.

After recording the desired number of training the episodes, **leave the training loop** by tapping the home button to return to the **Skill Details** page (See section 5.3 'MIRAI Cloud Training and Skill Versions').

4.2.3 Training a Motion Skill

4.2.3.1 Before Recording an Episode

Warning

During the training process, robot movement can be controlled by hand-guiding. If **hand-guiding is activated**, the robot can be moved in any direction. Please pay attention to not squeeze your free hand and fingers by accident or shear any body parts. Be especially careful when the robot is handling workpieces with sharp edges or pointed contours.

(1) With the newly created skill in the home screen, tap on the 'Open' button on the right-hand side of the new skill to enter the "Details" screen.

Local skills	All skills	Add new s	kill +
ast updated: 26.09.2023.	3 - 16:27		
Test Skill Motion Motion skill Modified: 26.09.2023 - D4:02 Cloud epitodes 5 Local episo	Skill versions 01 det 5	Open	I
Test Skill Position Positioning skill Modified: 26.09.2023 - 01.58 Cloud episodes 5 Local episo	ning Bill venices 01 dets 5	Open	I
Cloud training in progress 1 ho.	ur and 15 minutes remaining		
Cloud training in progress 1 hos	ur and 15 minutes remaining		
Doud training in progress 1 hor	ur and 15 minutes remaining		
Choud training in progress 1 hos	ar and 15 minutes remaining		

'Details' screen contains information about the skill and the steps to create it.



2 In the 'Details' screen tap on the "Record episodes" button to enter the training loop.

Datalla Falandar (1)			
Details Episodes Si	kill versions		
Skill Information			Ŷ
	General:		
	Skill-ID:	026145257	
	Skill type:	1920143237	Robot:
	Positioning ski	11	UR5e
Reference image Camera 1	Axis translation Translations ()	ns: (, Y, Z)	Axis rotations: (X, Y, Z)
	Camera:		
	Number of car Dual camera	neras:	
Reference image Camera 2	Gain Camera 1 1	:	Exposure Camera 1: 5000
	Gain Camera 2 1	E	Exposure Camera 2: 5000
	Tool		
	Tool name: Tool Test		
	TCP Displacer	nent:	
	X: 8 mm	Y: 0 mm	Z: 5 mm
	RX: 4.0 rad	RY: 0.0 rad	RZ: 0.0 rad
Collect data		_	
Record enough episodes to cov	ver all the relevant	ſ	Record episodes

3 Before beginning to record a new episode, please **ensure that the robot is in a correct starting position**, either by sending the robot automatically to the predefined reference position ('Send to reference position') or manually guiding it to a user defined starting point ('Manual positioning').

← Skill Training Motion	Skill: test motion 3 (0)	← Skill Training Motion	Skill: test motion 3 (0)
Please reposition the robot	to begin an episode.	Please reposition the robot to b	egin an episode.
Send to reference position	O Manual positioning	© Send to reference position	e Manual positioning
		Warning! Pressing this button will cause the robot own accord. Please make sure you sta nothing will get in the way of the robot reference position. Cancel There read the warn robot to the r	st to move on its nd clear, and that returning to its ing and want the move
Calibration Reference position	≅ ⑦ Guiding sensitivity Help center	Calibration Reference position Guidi	

(4) Remove hands from robot to **calibrate the F/T sensor** and tap on 'Calibrate F/T sensor' to proceed.

← Calibrating Mot	ion		Skill: test motion 3 (0)
Important: F your hands b	Please ensure before calibrat	robot arm is fr ing.	ee, remove
	ⓒ Calibrate	F/T sensor	
0	÷	=	0
Calibration	Reference position	Guiding sensitivity	Help center

- (5) Before recording, **check the image preview** and guide the robot through the intended trajectory, keeping in mind the following points:
 - * Make sure that during the entire path, the camera can 'see' the target object(s) and the tool.
 - Ideally, keep distracting objects out of the view, such as hands or task-unrelated objects.
 (While it is possible to train reliable skills even in the presence of distractors, it comes at the cost of increased demonstration effort).
 - * You can adjust the guiding sensitivity by tapping on the Guiding Sensitivity button in the bottom bar. Please see section 4.4 Guiding Sensitivity for more details.
 - * The camera grid feature (found at the top right corner of the camera view) can help with positioning the robot more accurately or easily.



6 Tap on to add a text label. You can tag the episodes or series of episodes with meaningful names that best describe the condition, environment, or the object. This will help you plan and keep track of your recording steps. Please see section 4.6 'Adding Tags or Text Labels for Episodes' for more details.

4.2.3.2 Recording Episodes

- 1 Press 'start recording'.
- (2) Immediately, guide the robot to perform the desired motion. Make sure that **the movements are smooth**, **direct**, **and straight**.
- (3) Tap on 'Stop Recording' once the task is done. The counter gives you an indication of the total time recorded. The recordings are usually shorter; the maximum limit for recording is 3 minutes.



(4) If the episode recorded is optimal, select 'Save' to save it; if not, choose 'Discard' to delete it.

← Skill Training Motion	Skill: test motion 3 (0)
Save or discard current epi	isode?
Save	Discard
+ 10	

Discard the episode if:

- * the task could not be completed.
- * there were any pauses in the motion, or if the motion contained unplanned detours/deviations from the direct path.

The system will try to imitate all recorded motions faithfully - so smooth recordings yield smoothly running production skills.

i Note

The **episode counter** (on the top right corner of the screen, in brackets) shows the number of good recordings collected so far.

⁽⁵⁾ **Calibrate the F/T sensor**. This measure is required after every episode to avoid drifting during guiding.



6 **Choose a different starting position** and tap on 'Start recording' to proceed with the next episode. The number of successfully recorded episodes is indicated on the top-right corner.



Ensure that all variances are captured in order to derive a meaningful and functional skill. Capture

relevant variances in around 150-200 episodes to expose the skill to the spectrum of changes and variances that are expected to be seen in the setup during execution (this usually takes about 2-5 hours, depending on the complexity of the task, the skill of the trainer, and the breaks the user takes).

After recording the desired number of training the episodes, leave the training loop through the home button (top left corner) which opens the 'Details' overview screen.

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!**

4.2.3.3 Training Tips

To achieve good results (a MIRAI skill that is effective and robust in handling dynamic changes and variances within the setup), it is important to pay attention to how to train the robot and capture this through the camera(s) across various recordings. The initial episodes you record will teach MIRAI to find the target position. Subsequent episodes will teach MIRAI how to find the target while handling variances in the environment.

♀ Tip:

It is helpful to imagine that everything the systems 'sees', i.e., captured in the recorded episodes and rated to be used, will impact the trained behavior, for the better or the worse.

Following is an overview of training tips for demonstrating and recording episodes:

- Each episode should include some form of variation for MIRAI to learn from. MIRAI does not learn from being shown the same thing twice. Consider the sources of variance in your application (for more details see section 4.3 'Sources of Variances').
- **Hand placement:** Place your hand just below the Force/Torque sensor along the robot arm. An episode will fail if your hand falls into the field of view of the cameras be very mindful of this while rotating!
 - Holding the wrist near the F/T sensor ensures that even tiny motions from the tip of the tool/gripper are properly captured in the training. Reaching from higher will be more difficult to steer and may result in more jerky or unpredictable pathing.
- **Pick a consistent strategy and stick to it:** For best results, avoid showing the AI two different paths to reach the same target. When you show the system more than one path, it can't decide which way is best and ultimately will try to blend these two paths together creating a "middle path" and fail. We recommend moving along the shortest path from the starting position to target position, whenever possible.
- **Move with a consistent speed:** MIRAI will pick up any inflections in speed along a path or during a motion. For example, when moving the tool, it accidentally moved too quickly in the beginning and then changed to a slower rate towards the end of the episode the AI will copy this motion identically. If your desired result is to maintain a smooth and consistent rate of speed, this will need to be properly demonstrated in your training episodes.
- **Be ready to 'Stop recording':** When setting up your workstation, tablet placement will help your trainings run much more efficiently and lead to fewer failed episodes. We recommend placing the tablet within reach so that you can quickly tap "stop recording" as soon as your episode is complete.

This will be especially important when training motion skills. Any delay at the end of the episode will be mimicked when performing the skill later. For this reason, make sure to press the 'Stop recording' button the moment the task is done; do not wait.

- **Avoid random motions and actions** that are not related to the task. To achieve effective trajectories (fast, shortest path possible), movements and trajectories demonstrated in the episodes should represent these trajectories. The MIRAI skill will reflect the trajectories that will be recorded.
 - Do not record trajectories that are non-optimal (including unnecessary pathways) or that vary highly from one recording to the other (in case there is no reason for doing so).
 - Do not move the robot tool into areas and orientations where it should never go while recording episodes.
- **Do not collide with the target** during training. This is likely to displace the target and the tool, creating bad data.
- Train for overshoots:
 - Show MIRAI what it looks like to overshoot the target. For example, what it looks like to move past the target, above the target, below the target, to the side of the target, or around the corner from the target etc. Start from unlikely positions. Showing MIRAI what an overshoot looks like is the key to teaching it how to recover from an overshoot.



Example of Overshooting the Target

Figure 7: Overshooting the target

- For about a third of the recordings, place the robot in a starting position slightly besides the ideal path. Example: In a task that involves touching a target object, an ideal motion path is one that does not overshoot, i.e., the robot never travels beyond the target. Nevertheless: Do start some recordings from positions slightly beyond the target - demonstrating how to find back to the target, just in case.
- It is important to start these 'recovery recordings' with the robot already positioned in a
 point besides the ideal path if instead, you start from the same start position as in normal
 episodes, only deviating into the weeds somewhere along the way, then the system would
 learn to perform this deviation during normal operation, which would be undesirable.
- In other words: During the setup phase, pretend that a small mistake has already happened. Then, during recording, teach just how to correct it.

 Save backups of your MIRAI controller: It is good practice to occasionally create backups of your MIRAI controller – especially once you have developed your skill to a satisfactory level. In the event that your MIRAI controller gets damaged or destroyed, it is helpful to have a backup of your MIRAI controller so that it may be easily restored. Creating a backup requires a USB flash drive – see chapter 11 'Backup and Restore'.

4.3 Sources of Variances

In order to receive a robust skill that deals with the variances in the setup and the task, it is required to capture these variances (ideally including their border cases) across the training episodes. The following are some sources of variances that are often encountered in automation tasks:

- Variations in the start and end points of trajectories in the task
 - Will the skill deal with varying positions of certain objects, relative to the camera? Note the range of possible object configurations that might occur in production. What are the extreme positions? Change the object positions between recordings, so that the recordings cover the full range of possible object positions in between those extremes, without 'gaps'. This can either be done systematically (e.g., moving objects row-by-row on an imagined grid in small increments) or in random order (e.g., if object positions are determined by an upstream process component).
- Variations in the color or/and shapes of the working parts
 - Will the skill deal with varying appearances of certain objects, for example, varying corrosion patterns, varying colors, or shape irregularities? If so, regularly change the setup in between recordings so that the 200 recordings cover a wide variety of object appearances or shapes.
- **Changing background** or moving objects in the background (only relevant if the background is visible in the recorded episodes)
- Changes in **lighting conditions**, e.g. changing daylight, etc. Direct exposure to sunlight will likely have a negative impact on the robustness of the skill and should be avoided if possible.
- Imprecisions and variations in gripping positions at the TCP

4.4 Guiding Sensitivity

i Note

This feature is not available for skills which are operating without a F/T sensor.

You can change the guiding sensitivity according to your preferences. Click on the "Guiding Sensitivity" button in the bottom bar. Start recording screen (before recording) to adjust the guiding sensitivity for rotational and translational movements. For skills with rotations, you might want to make it less sensitive (or 'stiff') in order to get a smooth and controlled trajectory. Tap on 'Apply Settings', and then move the robot arm to check if the settings are fine.



i Note

It is recommended **not to use the maximum sensitivity with large robot models** like R-2000iC/165F/210F and R-2000iC/270F.

4.5 Help Center

Tap on the 'Help Center' icon in the bottom bar to get tips on training motion skills, to know about typical variance and avoiding common mistakes.

Robot Training Motion skill		Skill: nev	v release test 1 1cam 4551
Plaase reposition the re	bot to	bogin an onig	odo
riease reposition the re			
	_		
Motion skills - How to train			
Tips on how to record good data for your traini	na		
The officer of the officer officer of the officer off			
Turinel union and			
Typical variances	I ob our beiltat		:
An overview of the typical variances you should	I STOW MIRON		
Common mistakes			:
the second second and the second			
what to avoid in order to train a rooust skill			
what to avoid in order to train a rooust skill			
		=	(7)

To get tips on how to record good data for your training, click on the 'Motion Skills – How to train' option from the Help Center pop-up in the bottom bar.



To get an overview of the typical variances you should show MIRAI, click on the Typical Variances option from the Help Center pop-up in the bottom bar.

Robot Training Motion skill	Skill: new release test 1 1cam 4551	Typical variances
Please reposition the robot to b	oegin an episode.	Some aspects of your task are slipitly different every time (which is why you're using MIRA). We can those changing aspects variances. You can teach MIRAI to react to them (for example, moving to th target object that is an adflerent place every time), and you can teach to joince them (for example moving to a target object even if it has alferent calces every time).
		It is recommended to make a list of variances you would like MIRAI to handle and plan your training cover them all. If you went MIRAI to process constraining, e.g., the background you have to explicitly teach it to do so - that means that you have to record background variation. This as an overview of typical sources of variance to keep in mind. Target object:
		How does the target object change between executions? On how many axes can be location and einstandor many? Oces is come in different shapes or colors? In its non objec? Are there multiple objects? Are they of the same type or all different? Other is noneen
		Can its pose in the gripper change?
		Background
		 Could the background as seen by the camera change over time? Is it uniform or patterned? Are there moving objects (people, vehicles, other robots, changing monitor displays etc)?
Motion skills - How to train		Lighting
Tips on how to record good data for your training	>	Will the lighting change? (different light sources, day/night.) Is it sumy or stady? Is the overfined light on or oft? Is the overfined light?
Typical variances	>	We recommend:
An overview of the typical variances you should show whom		Count the number of variances in your task Plan to record roughly twice the additional data for every added variance Between every recording, randomb yarrange the items that can vary
Common mistakes What to avoid in order to train a robust skill	>	
Calibration Reference Position	프 (?) Guiding Sensitivity Help Center	

To know more about avoiding common mistakes in order to train a robust skill, click on the Common Mistakes option from the Help Center pop-up in the bottom bar.

Bobot Training Motion skill	Skill: new release test 1 1cam 4551	← Common mistakes
Please reposition the robot to b	egin an episode.	1 - The lighting conditions are insufficient
		2 - The camera settings are suboptimal
		3 - The camera is too far away
		4 - The camera angle is suboptimal
		5 - The task is too broad
otion skills - How to train a on how to record good data for your training	>	6 - Not planning the training
ypical variances overview of the typical variances you should show MIRAL	>	7 - Hands are in the camera image 🗸 🗸
ommon mistakes at to avoid in order to train a robust skill	>	8 - The target is not in the camera image \sim
Calibration Reference Position	E (?) Guiding Sensitivity Help Center	9 - Ignoring the background

4.6 Adding Tags or Text Labels for Episodes

You can add "tags" or labels for each episode you record. Please note that **this is not mandatory for training a skill**, but it is recommended to add tags or labels to better organize and structure episodes. For example, tags can help keep track of the following instances:

- Variance in lighting conditions. E.g., "sunlight", "spotlight", "cloudy"
- Variance in the color, shape or appearance of the target object. E.g., "red", "rectangle"
- Variance in different starting positions or angles, E.g., "left", "up", "top-right"
- Changing background or moving objects in the background
- · Adding tags under the name of the person who recorded episodes
- "trial" or "practice" episodes
- Tagging "recovery episodes", where the robot is already positioned in a point besides the ideal path. In other words, show the robot how to correct a mistake.
- Indicating who did the respective recordings in case several people are working on a skill

Depending on your task, you would most likely use the same set of tags for multiple episodes. Please note that the maximum limit on the number of tags is 'ten'; each episode can have up to ten tags. The total tags associated with a skill however can be more than ten.

The following steps give you step-by-step instructions:

1) Before you start recording a new skill, tap on the two button.



2 On the pop-up screen (see below), select the tags from the existing list or add a new tag.

MIRAL Robot Training	Skill: test skill (C)		AI Robot Training	Skill: test skill (0)
Add Tags Ep. 1 First Control of		e kun evoren Befo targe	Al Recent Haining	Shift for hill (0)
Done			_	
← Back			ck	

(3) The selected tags are shown at the top of the screen. Tap 'Done' once you have added all the tags. You can also modify these tags later.



4 Proceed with recording the episodes. You can also modify the tags before selecting 'Save' or 'Discard', by tapping on the '+ Tags' icon.

MIRAI Robot Training	Skill: test skill (0)	MIRAI Robot Training	Skill: test skill (0)
Save or discard current episode?	Sa	ve or discard current episode?	
Use for training	card	Add Tags Ep. 1 (verver 👻) (newer verver) Add newe tag vertice verver) verver verver) verver verver ver	
t ap (mm) (mm)	. 1		

⁽⁵⁾ Proceed with recording the subsequent episodes. Note that the tags that you selected from the previous episode are automatically carried over to the subsequent episodes. You can add or remove tags immediately before or after the next episode is recorded.



6 Once you have recorded all the episodes, on the skill overview screen, you can review or modify tags. Tap on the 'Episodes' tab.

Details	Episodes Skill versions	
_		∓ Filter
pisodes (7)		
Trash (0)	# 01 Recorded: 09.09.2022 - 17:18:54	I
	# 02 Recorded: 09.09.2022 - 17:21:13	I
	# 03 Recorded: 09.09.2022 - 17:22:55	ī
	# 04 Recorded: 09.09.2022 - 17:26:32	I
	# 05 Recorded: 09.09.2022 - 17:28:52	I
	# 06 Recorded: 09.09.2022 - 17:31:28	I
	#07 Recorded: 09.09.2022 - 17:35:36	1

? Open the three-dot menu and select "Edit tags" to add or remove tags for the respective episode.



8 To manage tags, on the main screen, go to the top left menu and select 'Tag Management'.



Tap on the "edit icon" to rename a tag. Please note that this would mean updating the tag name across multiple episodes, possibly across different skills.

'ag Management	÷	Tag Management	
All tags		All tags	
Tags name		feb111	
yellow		vellow	
cloudy		Rename tag	
red		yellowM Tag name	5
yellow		Tuesday	
Monday		Cancel	Done
		tags galore	
		123456789012345678901234567890	
		Tuesday	
		Ben	
		testt	

10 Tap on the "delete icon" to delete a tag. Please note that you can delete a tag once it is not associated with an episode.

Tag Management	÷
All tags	
This list displays all tags that have been created across all skills.	
Tags name	
yellow	
cloudy	
red	
yellow	
Monday	





5 Reviewing & Cloud Training

5.1 Checking Target Position Consistency

i Note

This feature is available for **positioning skills only**.

After recording 5 to 10 episodes to train a positioning skill, it is crucial to ensure that the target positions are consistent across all episodes before sending the training data to the Micropsi cloud. Consistent target positions are the key to achieving accurate MIRAI skill execution. For details, refer to 2.4 Quantify the Target Position). Follow these steps to check your data using Target Frame Review:

1. Open Target Frame Review:

- Navigate to the Details overview screen. In Step 2: Review target frames, tap Start review to display the first frame of an episode – the "target frame."
- NOTE: You can only review local episodes. Episodes recorded on other controllers, such as in shared skills, cannot be reviewed.

Details Episodes Ski	ill versions		
Skill Information			
	General:		
	Cloud key:		Skill ID:
	377_16_202410	30154839	19278
	Skill type: Positioning skill		Robot: LR Mate 200iD/7L
Reference image Camera 1	Axis translation Translations (X,	s: Y, Z)	Axis rotations: (Z)
1			
2 <mark>4 - 4</mark> 2	Camera:		
	Number of cam Dual camera	eras:	
Reference image Camera 2	Gain Camera 1: 4		Exposure Camera 1:
	Gain Camera 2:		Exposure Camera 2:
	4		2500
	Tool		
	Tool name:		
	fanuc dimm 2		
	TCP displaceme	ent.	
	X: 0 mm	Y: 0 mm	Z: 290 mm
	RX:	RY:	RZ:
	0.0180	0.0 rad	0.0180
Step 1: Collect data		ſ	
Record enough episodes to cover conditions of your task.	all the relevant	l	Record an episode
Total number of locally recorded epis	odes: 5		
Step 2: Review target frames	3		
Flip through images taken at the	target pose of each	ive I	Start review
to many to prove of the NATE OF THE	a permune parme rela	1956 - C.	

2. Scan for consistency:

- For dual-camera skills, switch between the two camera views by tapping Switch camera view.
- Scroll through the images and note the position of the robot's end effector relative to the target.
 - Use the blue buttons to go through the images one by one:
 - > The right button moves forwards.
 - < The left button moves backwards.
 - \circ To quickly scroll through the images, press and hold one of the buttons.
- **Consistent Positions:** If the end effector's position is consistent across episodes, you will not notice any "jumps" or shifts in its position, although background elements like lighting or object colors may change. Consistent episodes can be sent to the Micropsi cloud to create a skill version.



3. Identify inconsistencies:

- Look for episodes where the end effector's position suddenly shifts compared to other episodes. These "jumps" indicate imprecise target positions.
- **Isolated Inconsistencies:** If you see only a few "jumps," delete these specific episodes by tapping **Send episode to trash**.
- **Frequent Inconsistencies:** If the target frame moves substantially with every new image, the training data are not consistent. In this case, you may need to start over.

4. Refine and Re-record:

- After deleting multiple episodes, you might need to record and review further episodes before sending the training data to the Micropsi cloud.
- Carefully define your target position and record several trial episodes.
- Review these trial episodes for consistency, ensuring the end effector maintains a constant position relative to the target.
- Continue this process until you achieve consistent target positions across all episodes.

Following these steps will make your training data more accurate and improve the execution of your skill.

5.2 Reviewing and Rerating Episodes

You can review the recorded episodes by replaying them. This allows you to regrade episodes, based on the potential issues during recording, for example, if the hand was in the camera view, or the lighting was sub-optimal.

Once you have recorded all the episodes, in the 'Episodes' screen, you can view the recorded episodes.



• Select 'View episode' from the three-dot menu of the respective episode and it will start playing automatically.

← test	Episodes Skill versions	I
		Filter
All episodes (5)		
Trash (2)	# 02 Recorded: 13.09.2022 - 15:26:36 (unrlight) (yellow)	View episode Edit tags
	# 03 Recorded: 13.09.2022 - 15:29:05 (90stepre) (surlight)	Send episode to trash
	# 04 Recorded: 13.09.2022 - 15:35:29 (velow) (Rodegree)	:
	# 05 Recorded: 13.09.2022 - 15:37:05 (nurlight) (908egree) (yellow)	:
	# 06 Recorded: 13.09.2022 - 15:39:03 (90stryree) (notight)	I

• In case there is some inconsistency in the recorded data, you can "discard" an episode by tapping the "Send episode to trash" menu item.

← test		I
Details	Episodes Skill versions	
		Filter
All episodes (5)		
Trash (2)	# 02 Recorded: 13.09.2022 - 15:26:36	: View episode
	# 03 Recorded: 13.09.2022 - 15:29:05	Send episode to trash
	# 04 Recorded: 13.09.2022 - 15:35:29 (yellow) (födtgree)	:
	# 05 Recorded: 13.09.2022 - 15:37:05 (autight) (Rolingues) (reline)	:
	# 06 Recorded: 13.09.2022 - 15:39:03	:

• To recover a discarded episode, go to the tab named "Trash" and select "Restore episode" menu item from the three-dot menu.

← test		I
Details	Episodes Skill versions	
		T Filter
All episodes (6)		
Û	#07 Recorded: 09.09.2022 - 17:35:36	i
Trash (1)		View episode
		Edit tags
		Restore episode

• You can search and focus on a relevant set of episodes by using the 'Filter' function. Filter the episodes according to the existing tags and tap on the "Show results" button.

← test		:	← test		÷
Details	Episodes Skill versions		Details	Episodes Skill versions	
		Filter			Filter
All episodes (5)			All episodes (5)		Tags ^
Trash (2)	# 02 Recorded: 13.09.2022 - 15:26:36 (unity) (vitor) # 03 Recorded: 13.09.2022 - 15:29:05 (00egare) (unity) # 04 Recorded: 13.09.2022 - 15:35:29 (vitor) (00egare) # 05 Recorded: 13.09.2022 - 15:37:05 (unity) (00egare) (vitor) # 06 Recorded: 13.09.2022 - 15:39:03 (vitor) (unity) (unity)	: View episode Edit tags Send episode to trash : : :	Trach (2)	# 02 Recorded: 13.09.2022 - 15.26 -: (might) (refer) # 03 Recorded: 13.09.2022 - 15.29 -: (otherwow (unlight) # 04 Recorded: 13.09.2022 - 15.35 -: (refer) (otherwow) # 05 Recorded: 13.09.2022 - 15.37 -: (unlight) (Refer) # 06 Recorded: 13.09.2022 - 15.39 -: (Recorded: Recorded: 13.09 -: (Recorded: Recorded: Re	sunlight 00degree yellow Clear all Save

• To modify the tags, tap on the 'Edit tags' menu item.

← test		I
Details	Episodes Skill versions	
		Filter
All episodes (5)		
1 Trash	# 02 Recorded: 13.09.2022 - 15:26:36	1
(2)	sunlight) (yellow)	View episode
		Edit tags
	# 03 Recorded: 13.09.2022 - 15:29:05	Send episode to trash
	(30degree) (sunlight)	
	# 04 Recorded: 13.09.2022 - 15:35:29 (yellow) (?050gree)	i
	# 05 Recorded: 13.09.2022 - 15:37:05 (sunight (Stateme) (yellow)	i
	# 06 Recorded: 13.09.2022 - 15:39:03 (sodegree) (zmight)	i

5.3 MIRAI Cloud Training and Skill Versions

A Important

If you are using a proxy to connect to the Micropsi cloud server, ensure it allows connections to the following hosts:

For training: https://crunch.micropsi-industries.com (TCP Port 443) https://crunch.micropsi.io (TCP Port 443)

For support: mirai-vpn.micropsi-industries.com (UDP Port 1194)

For software updates: https://apt.tools.micropsi.io (TCP Port 443) http://deb.debian.org (TCP Port 80) http://security.debian.org (TCP Port 80)

Details on the cloud connection and how Micropsi Industries handles data are in Chapter 12 Data FAQ.

i Note

The cloud training button will be active once you have recorded **at least 5 successful episodes** with at least 30 seconds worth of recorded data. The number of recorded episodes (for that version) are indicated in the "Collect data" section.

1 In the 'Details' overview screen, tap on the 'Start cloud training' button to trigger the calculation of a new skill version.

Skill Information		
and the second	General:	
	Cloud key: 72_16_20230922075003	Skill ID: 50849
	Skill type: Positioning skill	Robot: UR5e
Reference image Camera 1	Axis translations: Translations (X, Y, Z)	Axis rotations: (Z)
FC:	Camera:	
	Number of cameras: Dual camera	
Reference image Camera 2	Gain Camera 1: 1	Exposure Camera 1: 5000
	Gain Camera 2: 1	Exposure Camera 2: 5000
	Tool	
	Tool name: dimm tool	
Collect data		
Record enough episodes to cover conditions of your task.	all the relevant	Record episodes
Total number of locally recorded episo	des: 0	

2 After starting the training, the respective version will appear in the "Skill versions" screen.

← test			1
Details	Episodes	Skill versions	
The skill versic	n that is set to a	ctive will be the only one available in the	e native robot controller.
Please note: End states can	only be change	d within the active skill version, but will a	apply for all skill versions in this list.
Active			
All			
Version 0	1		
			Test & configure
			Set as active
Cloud training i	n progress		

Once cloud training has started, you will see 'Cloud training in progress' and the estimated time remaining written under the respective version. This process will take approximately 45 minutes. For dual camera skills it is double the time.

← tes	t .		1
Details	Episodes	Skill versions	
The skill ve	rsion that is set to a	ctive will be the only one availab	le in the native robot controller.
Please not End states	e: can only be change	d within the active skill version, b	ut will apply for all skill versions in this list.
Active			
A.II.			
All .			
Versio	n 01		
			Test & configure
			Set as active
Cloud train	ing in progress 25 minute	s remaining	

³ Once the skill version is available, you will see the text in green indicating that an updated skill can be tested and activated. "Skill versions" feature enables you to create different versions of the same skill to find out what works best for your use case. With skill versions, it is possible to activate one of the previous versions while still preserving the newer versions. To **activate the version of your choice**, tap on the "Set as active" button.

← test			
Details	Episodes	Skill versions	
The skill vers	ion that is set to	active will be the only one available	in the native robot controller.
Please note: End states ca	in only be change	d within the active skill version, bu	t will apply for all skill versions in this lis
Active			
All			
Version	01		
			Test & configure
Greened. 2.7	ADAMAN TATA		Set as active
Cloud trainin	g has finished, please I	est and configure the updated skill.	
Version	02		
			Test & configure
			Set as active
Cloud trainin	g has finished, please t	est and configure the updated skill.	

i Note

The displayed status info of each skill is updated every 15 minutes. By pulling the screen downward and releasing it again, you can refresh this information anytime.

← test			
Details	Episodes	Skill versions	
The skill versi	on that is set to a	active will be the only one available in	the native robot controller.
Please note: End states car	n only be change	d within the active s. P. ersion, but wi	ill apply for all skill versions in this list
Active			
Version 0	3		
			Test & configure
			Set as active
Cloud training	19:2022 - 01943 has finished, please to	ist and configure the updated skill.	Set as active
Cloud training	9/2022 - 01543 has finished, please te	at and configure the updated skill.	Set as active
Cloud training	9/2022 - UTA3	at and configure the updated skill.	Set as active
Cloud training	has finished, please to	nt and configure the updated skill.	Set as active
Cloud training All Version (9/2022 - 01:43	n and coordigons the systemed abilit	Set as active
Cloud training All Version (Created: 13)	9/2022 - 01943 has finished, please to 01 09/2022 - 13/39	et and configure The updated ABL.	Set as active Test & configure Set as active
Cloud training All Version (Created 13)	12222 - 0143 Ass fieldhed, please to 11 11	a ad configur the updated diff.	Set as active Test & configure Set as active
Cloud training All Version (Created 13) Version (92022-0043 449 (Robert, Joseph In 31 32 399 3022-1339	at and configure the updated date.	Set as active Test & configure Set as active
Cloud training All Version (Created 13) Version (Created 19)	11 12 12 12 12 12 12 12 12 12	et and configue the speland all.	Set as active Test & configure Set as active Test & configure

You may encounter the **following exceptions** and will see an error message indicating the reason why cloud training has not been successful. These could be:

- 'Error due to no data connection' please ensure that the connection of the MIRAI controller to the Micropsi cloud server is working and stable.
- 'Training data still being uploaded, cloud training will start once data upload is finished' the upload of the training data has not finished, yet. Please try again after a short period. In case this error persists, please check the connection of the MIRAI controller to the Micropsi cloud server.

5.4 State of Uploads

The data is intermittently transmitted from the MIRAI controller to the Micropsi cloud server in the background in case a WAN connection is available. This is indicated by the status icon C ("Training data upload in progress"). While the data is being transmitted, WAN/Internet should not be disconnected from the controller, and the tablet should be connected to the MIRAI-xx Wi-fi network of the MIRAI controller.

MIRAI Skill Overview		G
		Add new skill +
test Positioning skill		i
5 episodes trained	Start cloud training	Open
Modified: Tuesday Sep 27 12:10 Skill versions: 0		

The other possible states are:

- 🗇 Status unknown: connection issue: Check your internet and Wi-fi settings.
- No uploads in progress: It is safe to disconnect WAN/internet from the controller.

6 Testing, Refining, and Embedding MIRAI Skills

6.1 Testing Newly Trained or Updated Skills

In the skill detail screen, tap on the 'Test & configure' button and choose the skill version you want to execute, test and configure.

← testskill		← test :
Details Episodes Skill versions	Camera settings Set reference position	Details Episodes Skill versions
Skill Information	Delete skill	The skill version that is set to active will be the only one available in the native robot controller.
72_16_20220920131107 Skill-to Dual camera Number of cameras Translations (x, y, z)	Positioning skill Skill type UR10e Robot Rotations (z)	Please note: End states can only be changed within the active skill version, but will apply for all skill versions in this list. Active
Reference image Camera 1 Camera Settings 1 Camera 1 gain 1 Camera 1 gain 1 Camera 2 gain 1 Camera 2 gain	4000 Camera 1 exposure 5000	Version 01 Test & configure Created 27.09.2022 - 10.12 Set as active
Reference Image Camera 2		Cloud training has finished, please test and configure the spdated skill.
Collect data Record enough episodes to cover all the relevant conditions of your task. Total number of recorded episodes: 0	Record episodes	Created 27.09.2022 - 12.33 Set as active
Create skill version Start a cloud training with all or individually selected episodes to receive a skill	Start cloud training	Cloud training has finished, please test and configure the updated skill.
Test the trained skill When the cloud training is finished you can test the skill execution and configure it. Active skill version: N/A	Test & configure	G

2 Before you start testing a skill, **position the robot to a suitable starting point** by either sending it to the reference position (which was saved during skill creation) or manually guiding the robot arm. When working without a F/T sensor, navigate the robot with the teach pendant instead.

← Skill Training	Positioning	Sk	III: test positioning 5 (0)
S referen	e end to nce position	⊖ Manu position	al hing
Calibration	-Ð Reference position	프 Guiding sensitivity	(?) Help center

(3) If working with a Force/Torque sensor: Similar to the training loop, remove your hands from the robot arm, and ensure it is not pushing against any obstacles. Tap on '**Calibrate F/T sensor**' to prepare the test session. (This step is omitted when working without a F/T sensor)

← Calibrating Po:	sitioning	:	Skill: test positioning 5 (0)	
Important: your hands	Important: Please ensure robot arm is free, remove your hands before calibrating.			
	Calibrate	F/T sensor		
O	-) Reference porition	≓ Guiding constituity	(?) Hele conter	

- Guide the robot arm to a starting position that allows testing the new or newly updated skill. Ideally, this position represents a scenario similar to the original starting positions used during training or starting positions that are expected to be seen in the real world. Set up a variant of the task, e.g., repositioning or changing some objects exactly as during the training.
- (5) Check the **image preview** to ensure visibility, exactly as during training.

- 6 The **Execution Settings** (the various options to define end state conditions) are being covered in section 7 'Setting End State Triggers'.
- Tap the 'Start Skill Execution' button. A safety warning will appear once to inform that the robot will now be moving, controlled by the MIRAI system. Confirming the warning will start the skill execution the robot starts moving.

i Note

When working with a Force/Torque sensor in your robot setup: During the whole testing procedure (before and during skill execution), the **guiding feature is always enabled**, allowing the user to manually intervene if needed.

☆ Skill Testing Po	sitioning skill	Skilt. I	(_picking_w_bod_opticodes (10)	(n) Skill Testing Positioning skill	SHE M.picking.w.bod.episode
M_picking_	w_bad_episodes	Arks		Please reposition the robo	t to begin testing.
				® Send to reference position	€ Manual positioning
color_vision_1	1			Warning! Preserver of the bother set frame per in the way of the other cancel	ex file tobal to increase its own audited sees, and that noting self et array to a reference posterior d the warning and want the robot
	► Start sk	ill execution			to maxe
Θ	÷	e	Ċ	Ç →	ي ن

8 **Watch the execution of the skill**. Press the 'Stop Skill Execution' button to temporarily halt the skill execution. After the execution is stopped, the 'Start Skill Execution' button will appear again, so the skill can be restarted at any time.


9 When the skill reaches **one of the end state conditions**, it will automatically stop. The skill can be restarted at any time. The end state that triggered the skill execution to stop will be displayed at the bottom of the screen with the respective value when available. This information will remain visible until the next test session is started or the "x" to close is tapped. To set end states please refer to section 7 'Setting End State Triggers'.





- (10) Tap on 'Calibrate F/T sensor' to prepare the next test session (if working with a F/T sensor), and so on.
- (1) 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 section 6.2 'Steps to Improve a MIRAI Skill Through Additional Training' for details. Or look into these two sections for troubleshooting, 6.3 and 6.4, if you are experiencing specific problems.

6.2 Steps to Improve a MIRAI Skill Through Additional Training

It is common that a test run (see section 6.1 'Testing Newly Trained or Updated Skills') after the first training round uncovers weaknesses in the new skill. For example, motions might be imprecise in certain task configurations, or may overly depend on a particular lighting situation or object appearance. In all cases, the reason is that the situations in which the skill is still weak are not yet sufficiently represented in the recorded demonstrations. Therefore, the remedy is to record additional demonstrations focused on the situations in which the skill needs help.

- Enter the recording loop.
- Ensure the robot arm is at the correct start position.
- Remove hands from robot & ensure it is not pushing against any obstacles, then calibrate the F/T sensor using the on-screen button.
- Set up a variant of the task, e.g., repositioning or switching out various objects.
 - If the skill test revealed weaknesses for one particular kind of situation (such as one region
 of the work area, a particular lighting situation or object appearance), then most of the new
 recordings should show this kind of situation.
 - If the test revealed **overshooting behavior** (i.e., the robot travels towards the target, but instead of reaching it continues to travel beyond it), use half of the additional recordings to

train for overshoots - demonstrating how to find back to the desired position. For **Positioning skills** see end of section 4.2.1.4 'Training Tips' for more information and for **Motion skills** 4.2.3.3 'Training Tips'.

- Check the image preview to ensure visibility, exactly as during the first training round.
- Record a demonstration, as during the first training round.
- Guide the robot back to the start position.
- The process repeats itself with the calibration screen.
- Typically, substantial improvements are achieved with **50-200** additional recordings of this kind for Motions skills and **5-10** for Positioning skills.

Note

The more episodes you record, the shorter each episode can be – it is okay for refinement episodes to be only **30-45 seconds** long.



Figure 8: Decreasing length of episodes

- Refinement episodes do not need to cover as large of an area as the initial episodes you record refinement episodes can be limited to the specific weak spot or area of variance that you are trying to teach MIRAI.
- Once the recording of episodes is finalized, **start another cloud training** by pressing the 'Start Cloud Training' button in the respective skill section. The status will change to 'Cloud training in progress' till the new skill update is delivered.

Word of advice:

The **confidence and competency** of the skill will increase with the **number of good episodes** that you record.



Figure 9: Additional training session flowchart

6.3 Troubleshooting Positioning Skills

Issues you may observe while testing the current skill version:

- The robot avoids taking a direct path from some specific area to the target?
 - This indicates that MIRAI has not been shown how to move along this specific pathway. Note that this rarely occurs with Positioning skills, as a direct path is generated automatically. It is only a problem if a large area is blocked or missing in the recordings.
 - * Fix: 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.
- The robot doesn't find its way to the target at all?
 - This indicates that the current camera image is completely unknown to the skill, and so MIRAI
 does not know how to get to the target from area on display. There could be different reasons
 why:
 - * **Fix:** Check your hardware first. Does the camera image appear normal? Could there be a reason that your camera image is blind? Is the camera mount or lens broken, is the light off?
 - * If the camera image looks good...
 - * Fix: Check your training plan next. Did you forget about a variance of your skill?
 - * If the training plan seems thorough...

- * **Fix:** 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?
 - There are two possible reasons for this to happen: The first option is that the camera is slightly offset.
 - * **Fix:** Use the camera realign feature (for more information refer to chapter 8.2 'Camera Settings').
 - * If the camera image is aligned...
 - This indicates that MIRAI does not have enough information about the areas close to the target and does not know how to recover from drifting near the target.
 - * **Fix:** Record new episodes that show MIRAI these nearby areas, by moving the robot to these areas from the target position.
- The robot does not want to rotate toward the target using certain axes of rotation/joints?
 - This indicates that MIRAI has not been trained to utilize specific axes of rotation when approaching the target from specific areas.
 - * **Fix:** First check that you have the required degrees of freedom for your skill enabled. If there are degrees of freedom missing, create a new skill with all the required degrees of freedom.
 - * If all the degrees of freedom required for this skill are enabled...
 - * **Fix:** Record new episodes that show MIRAI how to utilize all available axes of rotation, by moving the robot around the target 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/a part variation/or a part that looks different than
 others MIRAI was trained on, then this simply indicates that MIRAI needs to be shown the new
 part.
 - * **Fix:** Record new episodes using this new part/part variation.
 - * If this is a familiar part, then see the next possibility...
 - If the lighting has changed in your work environment, then this may indicate that MIRAI has not been trained under the current lighting conditions. Note that a change in room lighting should usually have a much greater effect than a small offset. However, a change in natural light due to a seasonal changes or different weather conditions can potentially be the reason.
 - * Fix: Record new episodes under the current lighting conditions.
 - * If the lighting in your work environment has not changed, then see the next possibility...
 - This may indicate that the aperture or focus has changed e.g., the set screws for the aperture/focus have fallen off the lens.
 - * **Fix:** Use the camera re-alignment feature to return the cameras to their original configuration (for more information refer to chapter 8.2 'Camera Settings'). Setup Cameras if necessary. Then iteratively execute a skill with different focus settings.
 - * If the camera alignment and the aperture/focus is correct...
 - This may indicate that MIRAI has been shown inconsistent target positions.

- * **Fix:** Check the target position for each episode by using the Target Frame Review feature (see Section 5.1 'Checking Target Position Consistency'). If you find episodes with incorrect target positions, delete those episodes and create a new version of the skill with the remaining episodes. If you have further questions, or require a more complete review, reach out to the Micropsi Engineering team.
- **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.
 - This may indicate that the cameras have become mis-aligned, or that the aperture/focus has changed – e.g., the mounting screws have loosened, the mounts got damaged, the set screws for the aperture/focus have fallen off the lens.
 - * **Fix:** Use the camera re-alignment feature to return the cameras to their original configuration (for more information refer to chapter 8.2 'Camera Settings'). Setup Cameras if necessary.
 - * If the camera alignment and the aperture/focus is correct...
 - This may indicate that the robots tooling has been damaged (specifically parts that are in the camera's FOV) e.g., gripper fingers are damaged, or the fixturing is damaged.
 - * **Fix:** Investigate your robot's tooling, as well as other relevant equipment in the workspace; replace damaged parts if necessary.
- **Unexpected movement direction while guiding:** During hand guiding or while recording an episode you may experience an issue where the robot moves against you or resists in the opposite direction.
 - This issue can happen if the Force/Torque sensor is not installed correctly.
 - * **Fix:** Make sure that the sensor has been mounted correctly. Refer to the printed symbols along the outside of the sensor, (e.g. +Y, -X). These must line-up with the robot flange.

i Note

On **FANUC robots**, the tool coordinate system is rotated by 90 degrees (see the MIRAI User Manual for FANUC Integration for more information).

6.4 Troubleshooting Motion Skills

Issues you may observe while testing the current skill version:

- The robot avoids taking a direct path from some specific area to the target?
 - This indicates that MIRAI has not been shown how to move along this specific pathway.
 - * **Fix:** Record recovery episodes that show MIRAI a path from this specific area to the target or trajectory, depending on the task. Recovery episodes are recordings that subsequently show the skill how to recover from a bad position.
- The robot doesn't find its way to the target at all?
 - This indicates that the current camera image is completely unknown to the skill, and so MIRAI does not know how to get to the target from area on display. There could be different reasons why:

- * **Fix:** Check your hardware first. Does the camera image appear normal? Could there be a reason that your camera image is blind? Is the camera mount or lens broken, is the light off?
- * If the camera image looks good...
- * Fix: Check your training plan next. Did you forget about a variance of your skill?
- * If the training plan seems thorough...
- * Fix: Record new episodes which show MIRAI this area, by moving the robot from this area to the target position.
- The robot reaches a point near the target and then drifts away?
 - There are two possible reasons for this to happen: The first option is that the camera is slightly offset.
 - * **Fix:** Use the camera realign feature (for more information refer to chapter 8.2 'Camera Settings').
 - * If the camera image is aligned...
 - This indicates that MIRAI does not have enough information about the areas close to the target and does not know how to recover from drifting near the target.
 - * **Fix:** Record new episodes that show MIRAI these nearby 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/joints?
 - This indicates that MIRAI has not been trained to utilize specific axes of rotation when approaching the target from specific areas.
 - * **Fix:** First check that you have the required degrees of freedom for your skill enabled. If there are degrees of freedom missing, create a new skill with all the required degrees of freedom.
 - * If all the degrees of freedom required for this skill are enabled...
 - * **Fix:** Record new episodes which involve rotations through each available axis. This will show MIRAI how to utilize all available axes of rotation.
- The skill places the robot tool off-target in a consistent way?
 - If the skill is being performed on a new part/a part variation/or a part that looks different than
 others MIRAI was trained on, then this simply indicates that MIRAI needs to be shown the new
 part.
 - * **Fix:** Record new episodes using this new part/part variation.
 - * If this is a familiar part, then see the next possibility...
 - If the lighting has changed in your work environment, then this may indicate that MIRAI has not been trained under the current lighting conditions. Note that a change in room lighting should usually have a much greater effect than a small offset. However, a change in natural light due to a seasonal changes or different weather conditions can potentially be the reason.
 - * Fix: Record new episodes under the current lighting conditions.
 - * If the lighting in your work environment has not changed, then see the next possibility...
 - This may indicate that the aperture or focus has changed e.g., the set screws for the aperture/focus have fallen off the lens.

- * **Fix:** Use the camera re-alignment feature to return the cameras to their original configuration (for more information refer to chapter 8.2 'Camera Settings'). Setup Cameras if necessary. Then iteratively execute a skill with different focus settings.
- * If the camera alignment and the aperture/focus is correct...
- This may indicate that MIRAI was trained with bad data for example, if inconsistent target positions or not enough 'recovery episodes' near the target position were recorded.
 - * **Fix:** Request a data review from the Micropsi Engineering team if bad start frames are found in your skill version, they will inform you of what episodes to delete. Once you have deleted the bad episodes, create a new version of your skill with the good episodes.
- **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.
 - This may indicate that the cameras have become mis-aligned, or that the aperture/focus has changed – e.g., the mounting screws have loosened, the mounts got damaged, the set screws for the aperture/focus have fallen off the lens.
 - * **Fix:** Use the camera re-alignment feature to return the cameras to their original configuration (for more information refer to chapter 8.2 'Camera Settings'). Setup Cameras if necessary.
 - * If the camera alignment and the aperture/focus is correct...
 - This may indicate that the robots tooling has been damaged (specifically parts that are in the camera's FOV) – e.g., gripper fingers are damaged, or the fixturing is damaged.
 - * **Fix:** Investigate your robot's tooling, as well as other relevant equipment in the workspace; replace damaged parts if necessary.
- **Unexpected movement direction while guiding:** During hand guiding or while recording an episode you may experience an issue where the robot moves against you or resists in the opposite direction.
 - This issue can happen if the Force/Torque sensor is not installed correctly.
 - * **Fix:** Make sure that the sensor has been mounted correctly. Refer to the printed symbols along the outside of the sensor, (e.g. +Y, -X). These must line-up with the robot flange.

Note

On **FANUC robots**, the tool coordinate system is rotated by 90 degrees (see the MIRAI User Manual for FANUC Integration for more information).

6.5 Adjusting or 'Tuning' the Speed of the Skill

Adjust the execution speed (up to the maximum speed supported) in order to improve the overall tact time. This section allows you to set the standard speed for your skill. The advanced settings allow you to further fine-tune the speed profile.

(1) On the screen shown below, tap on the 'Execution Settings' button.



2 Select 'Execution speed'.



(3) The graph illustrates the acceleration speed. The default value is x1 (i.e., 1 times) of the speed at which the skill was recorded. Move the slider towards left or right to **change the execution speed**.

Exec	zution Speed
Esecution speed	Libered [1
-	Execution time Accelerated execution speed (high speed)
Accelera	ted execution speed (High speed)
-	Advanced Speed Profiles
Timespa	x 1.00 x 1.00
min. 1000	500.0 ms
Timespi	an on deceierated speed before End State

Gelect the 'Advanced speed profiles' checkbox to **proceed to the advanced settings**.

i Note

The Advanced speed profiles feature is currently not available for Positioning skills.

Image:		cution Sp	eed		
	Execution speed				Endatate
		×1 st	seed		
Accelerated execution speed (High speed) Accelerated execution speed (High speed) Advanced Speed Profiles Decelerated execution speed (x 0.5 - x 2.0) Transpan of deceleration S00.0 ms ms. 100ms Transpan on decelerated speed before End State	Ŧ	Accelerate Timespan	ed execution speed (High speed) of deceleration	Decelerated execution Timespan on decelera	speed (Low speed) ted speed
Advanced Speed Profiles Deseivated execution speed (x 0.5 - x 2.0) Transpan of deceleration 5000 ms mr. 190 ms Transpan on decelerated speed before End State	Acceleri	ated exect	ution speed (High speed)		×1.44
Advanced Speed Profiles Deceivated execution speed (x 0.5 - x 2.0) Transpan of deceivation 500.0 ms ms 100ms Transpan on deceivanted speed before End State					
Trivespan of doceleration Social ma mn Mode Trivespan on decelerated speed before End State					
500.0 ms mr. 1001 ms Timespan on decelerated speed before End State	Decelera	Advan-	ced Speed Profiles ution speed (x 0.5 - x 2.0)		
Timespan on decelerated speed before End State	Deceleri Timespi	Advan- ated exec	ced Speed Profiles ution speed (x 0.5 - x 2.0)		× 1.00
	Decelera Timespa	Advano ated exec an of dece 500.0	ced Speed Profiles ution speed (x 0.5 - x 2.0) feration ms		x 1.00

⁽⁵⁾ The updated graph now illustrates the speed settings for the advanced speed profiling. You can now adjust the 'accelerated execution speed' to a maximum of x5. Move the slider to adjust the 'decelerated execution speed'.

i Note

Moving to the **orange/red zone** means that your skill will be executed at a high speed. Use this cautiously, first experimenting with safer speed execution values.



- 6 Set a value for the **timespan of deceleration**. (Refer to the explanatory sketch shown at the top of the screen) Note that this value is in milliseconds.
- ⑦ Set a value for the **timespan on decelerated speed** before end state, in milliseconds.
- 8 Review your settings, and then tap on the 'Apply Settings' button. You can now proceed with (or resume) skill testing.

6.6 Force Response

i Note

This feature **cannot be used** when operating without a Force/Torque sensor.

Force response helps define a force threshold that can be applied during skill execution. Only when force is applied above this value, the response to the force is activated.

 \bigcirc Tap on the 'Execution Settings' in the bottom bar and then choose 'Force Response'.

Skill Configuration and T	est Positioning skill	Skill: test skill
/m		
	V 10 m 2 m 2 m 2 m 2 m 2 m 2 m 2 m 2 m 2 m	
color_vision_1	100	
End States Cischier		
End state parameters allow you end condition.	to detect and end the execution of a skill when it reaches a target	>
Execution Speed		>
Adjust the execution speed (up) overall tact time.	to the maximum speed supported) in order to improve the	
Force Response	tied	
Define a force threshold that can this value, the response to force	n be applied during execution. Unly when force is applied above is activated.	,
0	-A	-
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~	-

(2) Enter the value of the **force threshold** (in Newton) that can be applied during execution, in the respective text box. The value of the force threshold should be in the range of **10 N to 200 N**.

← Force Response	← Force Response
Force Response  Force Response  Define a force threshold that can be applied during execution.  100 Heating Pret Verse, 2009  Pret Verse, 2009  Pret Verse, 2009  Researce of the robat walk step steps how force threshold, is case of an unplaced collision within the threshold range the robat walk step moving and can therefore cause distinge.	Force Response     Contract Response
Audu entinge	Apply settings

#### i Note

During skill execution, the F/T sensor is active to react to situations where collision might be likely. Certain applications require the application of force. With this setting, you can define a force threshold that can be applied during execution, and **only above this value the force response will be activated** and influence the robot motion.

# 6.7 Reporting Skill Execution Results using MQTT

Data on skill execution is valuable for performance benchmarking, process optimization, and troubleshooting. MIRAI can report execution data using MQTT. This section explains how to use MQTT to report skill execution results.

#### 6.7.1 Introduction to MQTT

MQTT (Message Queuing Telemetry Transport) is a lightweight data exchange protocol for IoT messaging. It uses a publish/subscribe model that decouples message senders (publishers) from message receivers (subscribers).

All devices (clients) communicate through a central **message broker**. The broker filters incoming messages from publishers and distributes them to subscribers based on **topics**, which are hierarchically organized keywords. Publishers send messages to specific topics, and subscribers receive messages by subscribing to those topics.

MQTT client: A device that uses MQTT.

- Clients that send messages are publishers.
- Clients that receive messages are subscribers.

**MQTT broker:** System coordinating messages between clients.

**MQTT topic:** A string that identifies and routes messages, organized hierarchically with slashes (/) as delimiter. Topics are case-sensitive.

#### 6.7.2 Reporting Execution Results via MQTT

After an MQTT broker is configured and reporting is turned on, data points will be published every time a robot program triggers a skill execution. Data will not be published when skill execution is triggered from the MIRAI Training App (for example, for test purposes).

The data points are published in two formats after a skill is executed:

- Individual Plain Strings: Each data point is published individually as a plain string with a numerical execution counter to the topic execution/trace/. For example, the true_fps value will be published to execution/trace/true_fps.
  - Use plain strings for simple sequential data reporting. The numerical execution counter tracks the order of messages.
- JSON String: All data points are published together in a single JSON string to the topic execution/V1, shown in the example below. Use JSON strings for more detailed reporting on multiple data points.

NOTE: Empty quotation marks indicate missing values, for example, skill_ID in the example JSON string.

Here is an example of a JSON string that gets sent to execution/V1:

```
{
  "metadata": {
    "system": "MIRAI",
    "version": "21.0.0 - v21.0.0",
    "client": "MIRAI-694",
    "message_type": "execution_data",
    "message_type_version": 1,
    "message created": "2024-11-25 12:36:11.928136",
    "message created utc": "2024-11-25 12:36:11.928136"
 },
  "execution data": {
    "skill_id": "",
    "skill_name": "TestSkill",
    "tracing_token": ""
    "execution_result": "timeout",
    "true_fps": 14.5876571183907,
    "start": "2024-11-06 12:35:10.484330",
    "stop": "2024-11-06 12:36:11.906119",
    "duration": "2.834158",
    "speed": 0.0,
    "force": 2.9068664672206093,
    "done_probability": 0.01613561142317873,
    "anomaly_score": -1,
    "distance_mm": 9223372036854775807,
    "distance_deg": 9223372036854775807
 }
}
```

The data points in the JSON string are listed and defined below:

Metadata

- **system:** The system generating the message.
- $\circ$  **version:**The version of the system.
- client: The client identifier.
- **message_type:** The type of message.
- message_type_version: The version of the message type.
- **message_created:** The message timestamp, formatted as YYYY-MM-DD HH:MM:SS.µs, given in the controller's local timezone, which defaults to Europe/Berlin.
- **message_created_utc:** The UTC message timestamp, formatted as YYYY-MM-DD HH:MM:SS.µs.

#### • Execution data

- skill_id: The identifier of the skill.
- **skill_name:** The name of the skill.
- tracing_token: A token for tracing skill execution.
- **execution_result:** The result of skill execution.
- true_fps: The true frames per second during skill execution.
- start: The start time of skill execution, formatted as YYYY-MM-DD HH:MM:SS.µs.
- stop: The stop time of skill execution formatted as YYYY-MM-DD HH:MM:SS.µs.
- duration: Duration of skill execution.
- $\circ~$  speed: The speed during skill execution.
- force: The force applied during skill execution.
- **done_probability:** The probability that the task is completed.
- **anomaly_score:** The anomaly score during skill execution.
- **distance_mm:** The distance in millimeters.
- distance_deg: The distance in degrees.

#### 6.7.3 Configuring MQTT Results Reporting

Set up Execution Results Reporting **before** implementing MIRAI into the robot program.

To configure the connection to an MQTT broker in the MIRAI Training App, follow these steps.

- 1. Access MQTT reporting settings:
  - a. In the main menu, tap Execution Results Reporting.



#### 2. Configure MQTT settings:

- a. In the Broker field, enter the IP address of the broker.
- **b**. In the **Topic** field, enter the topic for the messages MIRAI will publish. IMPORTANT: Topics are case-sensitive.
- c. Tap Save settings and turn on reports to configure MQTT.

#### 3. If your broker requires authentication:

- Enter the **username** and **password**.
- If a username and password are required, leaving the fields blank or entering them incorrectly will trigger an error pop-up displaying: "Something went wrong. Server Response: Not authorized." Tap **OK**, then review and adjust your settings to proceed.
- If no authentication is required, these fields can remain empty.
- 4. **Optional:** Configure the **Mask** parameter to exclude specific data points from reporting to the execution/trace topic.
  - To exclude a single data point like "skill name" write: execution/trace/skill_name
  - To exclude multiple data points, write each one in a comma-separated list like this: execution/trace/skill_name,execution/trace/skill_id
  - To exclude all individual data points, enter the topic here like this: execution/trace

#### 5. Apply settings and turn on reports:

- Tap Save settings and turn on reports.
- A green "Settings applied" message will appear under the button and a green "On" indicator will appear at the top of the page.
- After reporting is turned on, a **Turn off reports** button will appear at the bottom of the screen.
- If you modify the settings, you must tap **Apply settings** for the changes to take effect.

MIRAI • Execution Results Reporting	MIRAI · Execution Results Reporting
Execution result reports via MQTT of	Execution result reports via MQTT on
When configured, MIRAI will publish skill execution result data to the given topic. Individual values will be published to/execution/trace/\$value, a JSON summary will be published to/ execution/V1.	When configured, MIRAI will publish skill execution result data to the given topic. Individual values will be published to ./execution/trace/svalue, a JSON summary will be published to ./ execution/V1.
Broker*	Broker*
IP address or server name. Accepts: notation for port.	IP address or server name. Accepts: notation for port.
	automation
Topic*	Topic*
Base topic for all MIRAI-published messages, example: "shopfloor/robot1/mirai.	Base topic for all MIRAI-published messages, example: "shopfloor/robot1/mirai.
	topic/mirai
Isername	Username
This can remain empty for brokers that don't need authentication.	This can remain empty for brokers that don't need authentication.
Password	Password
This can remain empty for brokers that don't need authentication.	This can remain empty for brokers that don't need authentication.
Maak	Maak
This can remain empty. Comma-separated list of subtopics never to publish to. Example:	This can remain empty. Comma-separated list of subtopics never to publish to. Example:
"execution/V1" will prevent publication of JSON summaries.	"execution/V1" will prevent publication of JSON summaries.
Save settings and turn on reports	Apply settings Turn off reports
	Settings applied

### 6.7.4 Turning MQTT Results Reporting On and Off

MQTT results reporting can be turned off or on at any time. The current status is displayed at the top of the screen: **On** in green or **Off** in red.

#### • Turn off MQTT reporting:

- Tap Turn off reports.
- A pop-up message will appear asking for confirmation. Tap **Turn off reports**.
- At the top of the page, the status will change to **Off** in red.

#### • Turn on MQTT reporting:

- Tap Save settings and turn on reports.
- At the top of the page, the status will change to **On** in green.
- If you modify the settings, you must tap **Apply settings** for the changes to take effect.

Tapping **Apply settings** or **Save settings and turn on reports** will test the broker address. If the broker is offline or the address is incorrect, an error message will display: "Something went wrong. Unable to connect to MQTT broker at *<your broker>*" Tap **OK**, then review and adjust your settings to proceed.

IP address test	or server name. Accepts: notation for port.
Topic*	
Base top	① Something went wrong Unable to connect to MQTT broker at test:1883, username 'test'.
Usern ^{This car}	Error: Cannot reach the broker. url: http://192.168.101.1:6543/mint/set_mqtt_settings
test	ОК
Passwo	rd
This can re	emain empty for brokers that don't need authentication.

# 6.8 Implementing MIRAI Skills into the Robot Program

Please see the MIRAI Integration Guide for your preferred robot platform to implement and execute MIRAI skills in the robot program in the native controller.

- **Universal Robots:** To implement MIRAI Calls into the UR Polyscope program applicable, see "Using MIRAI Skills with UR Polyscope" in the MIRAI User Manual for UR Integration.
- **FANUC:** To add and synchronize trained MIRAI Skills on the FANUC controller, see "Using MIRAI Skills with FANUC Teach Pendant" in the MIRAI User Manual for FANUC Integration.
- **KUKA:** To add a MIRAI Skill in your KUKA program via the KUKA smartPAD, see "Using MIRAI Skills with KUKA" in the MIRAI User Manual for KUKA Integration.

# 7 Setting End State Triggers

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.

# 7.1 End State Triggers Used by MIRAI

MIRAI uses the following triggers for end state detection:

End State Name	Description	Best Use Cases
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.	<ul> <li>most cases (and therefore, can be enabled and tried first)</li> <li>when it is unclear which end state is the best</li> <li>when the visuals are clearly defined within the camera's field of view</li> </ul>
Proximity-based Available from version 16.0.0	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). <i>Notes:</i> The skill will only stop executing when all the specific criteria are met. This end state can only be used for positioning skills.	<ul> <li>most cases (and therefore, can be enabled and tried first)</li> <li>when it is unclear which end state is the best</li> <li>when the visuals are clearly defined within the camera's field of view</li> </ul>
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. <i>Note:</i> This end state is not available when working without an F/T sensor.	<ul> <li>For tasks which end by:</li> <li>touching a surface (e.g., end points for surface measurements or insertion)</li> <li>stopping a surface interaction (e.g., by reaching the end of a working area)</li> <li>dropping a part (e.g., after picking)</li> </ul>
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.	<ul> <li>For tasks which end by:</li> <li>slowing down or stopping when reaching a target position in space</li> <li>stopping after a successful insertion</li> <li>slowing down when reaching the end path (e.g., gluing, painting, etc.)</li> </ul>
TCP Position-based (Beta)	MIRAI recognizes the desired end state when the end effector crosses a defined plane. <i>Note:</i> This feature is released as a 'beta' version (accuracy is at $\pm$ 5mm on low speed setting ( $\leq$ 1)).	
Anomaly-based Available from version 16.0.0	An anomaly-based end state halts skill execution if the current image looks unfamiliar (based on a threshold you set). Using this end state can increase the reliability of your skill, by detecting conditions which were not encountered during training (e.g., changes in the lighting of an environment, tooling setup, materials used in production, etc.).	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.

#### Additional Important Notes:

- 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 (see chapter 9

'Shared Skills - Using a Skill on Different Setups for more details about this feature).

- How to use proximity- and anomaly-based end states for "old" skill versions. 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. If you would like to utilize these end states on a skill created via a MIRAI controller with an older version, you must:
  - Update your controller's software version to at least 16.0.0.
  - Start a new cloud training to create a new skill version.
  - Configure the new end states you would like to use.
- Implications when switching between "old" and "new" skill versions. After updating your MIRAI controller to version 16.0.0 or higher, the following should be considered:
  - "Old" skill versions will still not have proximity- and anomaly-based end states.
  - If you create "new" skill version (trained with MIRAI 16.0.0 or higher) and set it as active, then
    after doing so, decide to activate an "old" skill version again and change its end state settings,
    the proximity- and anomaly-based end state on the "new" skill version will be deactivated.

## 7.2 Configuring End States on MIRAI

Based on the information provided above, review your task at hand and determine which condition/s would best indicate when the final state of a successful skill execution is reached. To put in place a robust and reliable end state recognition for different tasks and use cases, triggers for the end states you choose must then be set and tested, and subsequently, adjusted if necessary.

- (1) Select the skill for which you want to set end states.
- 2 Once you land on the respective skill's 'Details' screen, select the '**Skill versions**' tab.
- (3) Ensure the skill version you want to work on is set as active, and then proceed by tapping '**Test &** configure'.

← dimm s	skill		1
Details	Episodes	Skill versions	
The skill version	n that is set to a	ctive will be the only one available in the native robot controller.	
Note End states can Synced skills w	only be set thro ill not include pr	ugh the active skill version and apply to all versions in the list below. eviously defined end states. These must be set again locally.	
Active			
Version 03	3		
		Test & configure	
		Set as active	
All			
Version 0	2		
		Test & configure	
		Set as active	
Cloud training h	as finished successf	aby.	
Version 0	1		
		Test & configure	
Created: 22.09		Set as active	

4 When you land on the 'Skill Testing' screen, tap the '**Execution Settings**' button.

← Skill Testing   Positioning skill	Skill: dimm skill (0)
Send to reference position	<b>O</b> Manual positioning
Calibration Reference position	표 신 Execution settings

5 On the Settings bottom screen, **select 'End States'**.

#### i Note

These options are not mutually exclusive. The other settings will be further discussed in section 6.5 'Adjusting or 'Tuning' the Speed of the Skill' and section 6.6 'Force Response'.

← Skill Testing   Po	sitioning skill		Skill: dimm skill (0)
Se referend	© nd to se position	e Man positio	) ual pning
End States • Inst End state parameters alk end condition.	ed w you to detect and end the exec	ution of a skill when it reache	s a target
Execution Speed Adjust the execution spe tact time.	ed (up to the maximum speed sug	aported) in order to improve th	he overall
Force Response Define a force threshold this value is the response	hat can be applied during executi to force is activated.	on. Only when force is applied	d above
Calibration	-> Reference position	로 Execution settings	U Set active skill version

6 Enable the end states you want to utilize, then configure them accordingly by following the

End States	← End States
Note: End states set for the active skill version impact all versions of that skill. Changes made in the active version will automatically apply for the other skill versions as well.	Trigger end state
	Below      Above  1.0      cm/sec
Visual end state recognition 3	
End state offset (0 - 1)	
0.55	
	<ol> <li>Move the robot arm to a position where the threshold should be defined.</li> <li>Click below to set this position.</li> </ol>
Proximity-based	Set position
A proximity-based end-state halts the execution of a MIRAI skill when the robot gets close to its arget. This causes MIRAI to terminate and hand back control to a robot program.	Select an axis. The threshold would be perpendicular to the selected axis. (See the sketch in tool tip).
To apply this stopping rule, set values for the proximity thresholds below. The skill will stop executing when all specified oriteria are met.	0.0 x-axis 0.0 x (mm)
Skill will stop if tool is less than 1.0 mm from target position	0.0 y (mm)
and less than 5.0 degrees from target position	() y-axis
figual a value bahrween 0 and 180 degrees	> e-axis 0.0 z (mm)
TCP force based 0	
Trigger end state	Anomaly-based
Below   Above 3.0 Newton	An anomaly-based end state halts skill execution if the current image looks unfamiliar. Using this end state can increase the reliability of your skill, as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).
Annly settions	Amlu sattions
which settings	Apply settings

#### instructions found in the respective subsections that follow (subsections 7.2 to 7.2).

- At the bottom of the screen (after the last end state option, i.e., Anomaly-based for Version 16.0 or higher or TCP position-based for lower versions), you will see 'Time settings':
  - * Under 'Activate End states after', enter a value in the field that defines the delay in seconds, after the start of skill execution, when the end state settings should be activated. This is done to prevent a wrong early end state detection that can happen while the robot arm is set in motion and is accelerating. The value is preset to '1' second, which should suffice for most cases.
  - * Under 'Time Skill Execution after', enter a value in the field that defines the maximum timespan (in seconds) in which a skill should be executed. This is meant to serve as a local timeout for a skill in case it does not reach a defined end state. After the timeout period, the skill will be automatically stopped by the system.

🔿 y-axis	0.0 y (mm)	
🔿 z-axis	312.7767 z (mm)	
An anomaly- Using this er during trainin To apply this the skill more Anomaly soc -2.0	nomaly-based assed end state halts skill execution if the co grant be detected in the relativity of your as grant be detected with more uses (e.g. state and state, set an anomaly score therehold use sensitive or unimalitie mages, while higher we threshold (~50)	urrent mage locks unfamiliar. III, as conditions that were not encountered main in quality of manufacturing materials), using the slider biolog. Lower numbers make numbers reduce this sensitivity.
		More sensitive
Time setti	ngs states after 1.0 S	
Timeout Skil	Execution after	

⁽⁸⁾ Once you have enabled and configured your selected end states, make sure to confirm them by tapping '**Apply Settings**' at the bottom of the screen; otherwise, the changes will be lost.

#### Visual End State Recognition

When the visual-based end state is enabled, you must **set a threshold value**. You can do so by using the slider or tapping the numerical value field on the right-hand side and manually typing your desired value. A higher value means the positioning at the end of the skill must match the images from the live camera feed and should be recorded as precisely as possible, while a lower value means the skill could stop significantly before the end state (e.g., A 0.55 value indicates that when MIRAI has reached 55% of the desired final position, the skill is then terminated).

Visual end state re	ecognition
End state offset (0 - 1)	
	0.55
Broximity-based	
- Proximity-based	
A proximity-based end-state halts target. This causes MIRAI to termi	the execution of a MIRAI skill when the robot gets close to its inate and hand back control to a robot program.
To apply this stopping rule, set valu when all specified criteria are met.	ues for the proximity thresholds below. The skill will stop executing
Skill will stop if tool is less than	1.0 mm from target position
and less than	5.0 oegrees from target position
and less than	tigut a value between 0 and 180 degrees
and less than	bu) organises from target position liquit a value between 0 and 180 degrees
and less than	au potrees from target postion Void a vale between
and less than TCP force based Trigger end state	su jogges from taget posson byde valuebere open till døgres
TCP force based Troper end state Below  Above	au jouges from target position     but till degree

#### **Proximity-based**

#### available from version 16.0.0

When utilizing the Proximity-based end state, you must **set values for the proximity thresholds (both in mm and degrees)**. In the boxes, enter the distance value from the target position based on where you want the skill execution to stop. For example, if you want the skill to stop when the tool is less than 1.0 mm and less than 5.0 degrees away from the target position, enter these values.

#### i Note

The skill will only stop executing when **all** the specific criteria are met. This end state can only be used for positioning skills.

the active version will automatica	e skill version impact all versions of that skill. Changes made in ally apply for the other skill versions as well.
Neural and state re	
visual end state re	
Proximity-based	
A provimity-based end-state balts	the execution of a MIRAL skill when the robat rate close to its
A provinity based end state haits i	the execution of a Minteri akin when the robot geta close to ita
target. This causes MIRAL to termi	nate and hand back control to a robot program.
To apply this stopping rule, set valu when all specified criteria are met.	nate and nand back control to a robot program. Jes for the proximity thresholds below. The skill will stop executin
To apply this stopping rule, set val, when all specified criteria are met. Skill will stop if tool is less than	use for the proximity thresholds below. The skill will stop executin
target. This causes when to termin To apply this stopping rule, set valu when all specified criteria are met. Skill will stop if tool is less than	use for the proximity thresholds below. The skill will stop executine
target. Ins causes which to termin To apply this stopping rule, set valu, when all specified criteria are met. Skill will stop if tool is less than and less than	uses for the proximity thresholds below. The skill will stop executing           1.0         mm from target position           5.0         degrees from target position
target. Inits causes Mikea to termina To apply this actopping rule, set wak when all specified criteria are met. Skill will stop if tool is less than and less than	uses for the proximity thresholds before. The skill will stop executing each for the proximity thresholds before. The skill will stop executing 1.0 mm from target position 50 degrees from target position bed a which befores bed a which befores
target. In the causes kink-in to termin To apply this storping rule, set via with when all specified criteria are met. Skill will stop if fool is less than and less than	ues for the proximity thresholds before. The skill will stop executing ues for the proximity thresholds before. The skill will stop executing 1.0 mm from target position 5.0 degrees from target position but the degrees
target. In scauses kinkai to termi To opply this solonging rule, set val, when all specified criteria are met. Skill will stop if tool is less than and less than	ues for the proximity thresholds before. The skill will stop executing ues for the proximity thresholds before. The skill will stop executing 1.0 mm from target position 5.0 degrees from target position bed a value between bed to the degrees
anget, fine causes where to terms to papely this stopping rule, set vak when all specified or iteria are met. Skill will stop if tool is less than and less than TCP force based	ues for the proximity thresholds before. The skill will stop executing ues for the proximity thresholds before. The skill will stop executing 1.0 mm from target position 5.0 degrees from target position bed a tild before.
Cooperative Section 2 (Cooperative Section 2) (Coopera	ease since the provided the second to be a code program. Less for the proximity thresholds below. The skill will stop executing 10 mm from target position 50 degrees from target position 100 to the provide the provided to the provided

#### **Force-based**

When enabling the TCP force-based end state, you must define whether the skill should be stopped **above or below the force value** indicated, as measured at the F/T sensor. The default force value is set to 3 Newtons; nonetheless, you can **enter a value between 0 to 100 Newtons**.

#### i Note

This end state trigger is **not available** when working without a Force/Torque sensor.

	tes
Trigger end	TCP force based  state
	TCP speed based 🥥
Trigger end	Above 1.0 cm/sec
1. Move the 2. Click bek	robot arm to a position where the threshold should be defined. w to set this position.
1. Move the 2. Click bek Set po Select an an (See the ski	robot arm to a position where the threshold should be defined. w to set this position. attion is. The threshold would be perpendicular to the selected axis. chr in tool tip).
1. Move the 2. Click belo Set po Select an au (See the ski	Induct arm to a position where the threshold should be defined, we to set this position. attion 
Move the     Click bek     Set po     Select an a     (See the ski     ·· v-axis     ·· y-axis	Instoct arm to a position where the threshold should be defined. we to set this position. atticm is: The threshold would be perpendicular to the selected axis. this in root (sp). 0.0 x (rmm) 0.0 y (rmm)
Move the     Click bek     Set po     Select an ar     (See the ski     y-axis     y-axis     z-axis	Instoct arm to a position where the threshold should be defined. we to set this position. attem is: The threshold would be perpendicular to the selected axis. the initial tipe: 0.0 x (rmm) 0.0 y (rmm) 312.7767 x (rmm)

#### Speed-based

When using the TCP speed-based end state, you must enter a **speed-based threshold value from 1 to 1000 (mm/s)**, then select whether the skill should be stopped **below or above the speed value** you entered.

End States	\$	
Trigger end sta	DP force based  atte (a) Above (b) Above (c) A	
Trigger end sta	CP speed based  ate Above 1.0 cm/sec	
TC     Ave the ro     Click below     Set positi     Select an axis.     (See the sketc	CP position based in  CP position based in  CP position where the threshold should be defined to set this position.  In  CP position based be perpendicular to the selected axis.  In tho teg.	
O x-socis	0.0 × (mm)	
O y-axis	0.0 y (mm) 312.7767 z (mm)	

#### **Position-based**

To set a TCP position-based end state, move the robot arm to **a position where the threshold should be defined**, then tap on the 'Set position' button in the app to set this position — the X, Y and Z value for this

position will automatically update. Afterwards, **select an axis (X, Y, or Z)**, and the threshold would be perpendicular to the selected axis.

#### i Note

This feature is currently released as a 'beta' version (accuracy is at  $\pm 5$ mm on low speed setting ( $\leq 1$ )).

TCP speed based Tigger and state Tep read state TCP position based <	← End States	← End States
<ul> <li>TCP position based Image</li> <li>Avector the toto tarm to a position where the threshold should be defined.</li> <li>Click below to set this position</li> <li>Seter threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to the selected axis.</li> <li>Clear threshold would be perpendicular to threshold would be perpendi</li></ul>	Trigger end state  Below Above 1.0 cm//sec	TCP speed based  Trigger end state  Below Above 1.0 cm/sec
	<ul> <li>TCP position based Imi</li> <li>1. Move the robot arm to a position where the threshold should be defined.</li> <li>2. Click below to set this position.</li> <li>Set position</li> <li>Select an axis. The threshold would be perpendicular to the selected axis. (See the sketch in tool tip).</li> <li>Set so (See the sketch in tool tip).</li> <li>y-axis</li> <li>0.0 x (mm)</li> <li>y-axis</li> <li>0.0 z (mm)</li> <li>2 axis</li> </ul>	<ul> <li>CP position based Im</li> <li>A wore th</li> <li>C tack belt</li> <li>Position based end state</li> <li>Set present the state</li> <li>A wards</li> <li>A wards<!--</th--></li></ul>
Anomaly-based  An anomaly-based end state halts skill execution if the current image looks unfamiliar.  Using this end state can increase the reliability of your skill, as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).  Anomaly-based  An anomaly-based end state halts skill execution if the current image looks unfamiliar.  Using this end state can increase the reliability of your skill, as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).	Anomaly-based An anomaly-based end state halts skill execution if the current image looks unfamiliar. Using this end state can increase the reliability of your skill as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).	Anomaly-based An anomaly-based end state halts skill execution if the current image looks unfamiliar. Using this end state can increase the reliability of your skill, as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).

#### Anomaly-based

#### available from version 16.0.0

When applying the anomaly-based end state, you need to set an **anomaly score threshold (which ranges from -5.0 to 0.0)** by using the slider on the screen. The default value is set at -2.0, where 1 in 100 familiar images will be categorized as unfamiliar. Choosing a <u>lower number</u> will make the skill <u>less sensitive</u> to unfamiliar images, while selecting a higher number will increase the sensitivity.

O y-axis	0.0 y ((11))	
O z-axis	0.0 z (mm)	
Anon	nalv-based	
An anomaly-base	l end state halts skill execution if th	e current image looks unfamiliar.
Jsing this end sta during training car	te can increase the reliability of you 1 be detected with more ease (e.g. o	r skill, as conditions that were not encountered changes in quality of manufacturing materials).
To apply this end : the skill more sen:	tate, set an anomaly score thresho sitive to unfamiliar images, while hig	Id using the slider below. Lower numbers make gher numbers reduce this sensitivity.
Anomaly score th	eshold (-5-0)	
2.0		_
Less sensitive		More sensitive
1 in 100 familiar ima	ges will be categorized as unfamiliar.	
Time settings		
Activate End state	es after	
1.0	s	
1.0	ution after	
Timeout Skill Exec		
Timeout Skill Exec 60.0	S	

#### i Note

Selecting values at either end of the scale can cause the end state to never stop your skill (i.e., selecting -5, where 1 in 100,000 images will be categorized as unfamiliar), or continuously stop your skill (i.e., selecting 0, where 1 in 1 familiar image(s) will be categorized as unfamiliar). That said, it would be best to **avoid choosing these extreme values**.

- End States	← End States
y saxis         0.0         y (mm)           z saxis         1000.0         z (mm)	y-axis     0.0     y (mm)       z-axis     0.0     z (mm)
Anomaly-based  An anomaly-based end state halls skill execution if the current image looks unfamiliar.  Using this end state can increase the reliability of your skill, as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).  To popy this end state, set an anomaly score threshold using the slider below from (-5) less sensitive to unfamiliar images to (0) more sensitive to unfamiliar images.  Anomaly score threshold (-5-0)  Summer State Stat	Anomaly-based  An anomaly-based end state halts skill execution if the current image locks unfamiliar.  Using this end state can increase the reliability of your skill, as conditions that were not encountered during training can be detected with more ease (e.g. changes in quality of manufacturing materials).  To apply this end state, set an anomaly score threshold using the slidler below. Lower numbers make the skill more sensitive to unfamiliar images, while higher numbers reduce this sensitivity.  Anomaly score threshold (~5-0)  Less ensitive
Warning           Selecting values at either end of the scale can cause the end state to continuously stop your skill (0) or never stop your skill (-5). We recommended avoiding these values.           1 in 100000 familiar images will be categorized as unfamiliar.	Warning           Selecting values at either end of the scale can cause the end state to continuously stop your skill (-5) or never stop your skill (0). We recommended avoiding these values.           1 in 1 familiar images will be categorized as unfamiliar.
Time settings Activate End states after 1.0 S	Time settings Activate End states after 1.0 S
Apply settings	Apply settings

# 7.3 Returning Values for MIRAI End States on the Robot's Native Controller

To determine how you can get the return values of the MIRAI functions called during skill execution on your robot's native controller (which will allow you to understand which end state caused the skill to stop), kindly check the following resources:

- Universal Robots: MIRAI User Manual for UR Integration, Section 'Polyscope Functions and Variables'
- FANUC: MIRAI User Manual for FANUC Integration, Section 'Returning Values of MIRAI Functions'
- KUKA: MIRAI User Manual for KUKA Integration, Section 'Returning Values of MIRAI Functions'

# 8 Features for Skill Management

Tap on the three-dot menu on the right side of the skill overview as shown below or on the right side of the respective skill card.

← Place_Cube_v1	1/22/020	÷		_Cube_v1	versione	F/T sensor configuration
Details     Episodes     Skill       Skill Information     Image: Comparison of the state of th	Versions General: Skill-10: 463_9_20230718092718 Skill type: Positioning skill Axis translations: Translations: Translations: Single camera: Single camera Gain: 1 Tool Tool Tool anme: EGK40	Robot: URSe Axis rotations: (Z) Exposure: 4500	Reference	e image Camera 1	General: Skill-ID: 463_9_20230718092718 Skill type: Positioning skill Axis translations: Translations (X, Y, Z) Camera: Number of cameras: Single camera Gain: 1 Tool name: EGK40	Camera settings Set reference position Remove from "Local skills" list URSe Axis rotations: (2) Exposure: 4500
Collect data Record enough episodes to cover a conditions of your task. Total number of locally recorded episod	II the relevant	Record episodes	Collect d Record en conditions Total numb	ata ough episodes to cover all of your task. er of locally recorded episode	I the relevant	Record episodes
Start cloud training Create a skill version from all cloud	episodes.	Start cloud training	Start clo Create a s	ud training kill version from all cloud (	episodes.	Start cloud training

# 8.1 F/T Sensor Configuration

#### A Important

Assure that the **camera settings are correct** before proceeding. Changing the Force/Torque sensor configuration without ensuring the camera image is identical to the one made during skill creation can lead to skills performing poorly and unpredictably.

- 1 Tap on the three-dot menu on the right side of the skill details page as shown in the previous section. Select 'F/T sensor configuration'.
- ⁽²⁾ Select the desired setting from the 'Change F/T sensor to' drop-down menu as shown below. If no F/T sensor is connected, only 'None' is available.

Ensure the comercia-	heen correctly realized to form	recording Changing the	force (forgue pappor	ouration
without ensuring the ca poorly and unpredictab	amera image is identical to the or sly.	he made during skill creation	on can lead to skills perfor	ming
hange F/T sensor to				
None				
ATI				
	Apply new force/tor	que sensor configuratio	n	

- 3 Make sure the right tool is selected.
- 4 To save changes, tap on 'Apply new force/torque sensor configuration'.

÷	MIRAI   F/T sensor configuration	C)
Ens with poo	ure the camera has been correctly realigned before proceeding. Changing the force/torque sensor co out ensuring the camera image is identical to the one made during skill creation can lead to skills per dy and unpredictably.	nfiguration forming
Chang	e F/T sensor to	
ATI		~
Tool		
EGK	40	~
	Go to tool configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	
	Apply new force/torque sensor configuration	

# 8.2 Camera Settings

#### i Note

If your setup includes **GigE cameras**, it is mandatory to configure their IP addresses to the correct subnet and select them in the network settings of the MIRAI Training App. For instructions on how to correctly configure the IP address of GigE cameras please refer to the Robot Integration Guides.

You must realign the camera to the initial position if the camera has been switched, moved, or disturbed to ensure that the skill continues to execute correctly and that new recordings have the same visual reference to the robot. This advanced setting allows you to **assign the cameras to the right view respectively and align the camera back to the reference picture**.



- (1) Tap on the three-dot menu on the right side of the skill overview as shown in the beginning of this chapter. Select 'Camera settings'.
- 2 Make sure the **right tool/end effector** is attached.
- ③ Select a **reference image** from the previous episode, assign it to the respective camera by selecting it from the dropdown menu.

MIRAI   Camera settings	Skill: tes
Camera 01	Camera 02
Be careful before proceeding! Any changes to the camera settings have an im Please make sure the right tool/end effector is You might need to adjust the focus and apertur was created (These are global settings!)	npact on all skills you have created attached e settings to the same values as when the skill
ease select a reference image	
ease select the camera that matches the view of	of the images above.
GigE - 700011106229	~
ljust your camera accordingly, bringing it as clo	use as possible to the reference image.
age frequency	

4 Adjust the camera position and focus to bring it as close as possible to the reference image. Even slight pixel deviations can have an immense impact on the quality of the skill so make sure to do the adjustment as accurately as possible.

	15		Skill: tests
Camer	a 01	Camera 02	
Be careful before proceet Any changes to the can Please make sure the ri You might need to adjus was created (These are	eding! nera settings have an impac ight tool/end effector is atta st the focus and aperture se e global settings!)	ct on all skills you have created iched ittings to the same values as when	the skill
Please select a reference i	image	te Images above.	
GigE - 700011106229		~	
Adjust your camera accorr	dingly, bringing II as close	as possible to the reference imag	e.

- ⁽⁵⁾ The camera view and the reference image will alternatively flash on the screen to help you bring the camera as close as possible to the original position. **The frequency of image flashing can be adjusted** to your comfortable level using the slider.
- 6 If the camera(s) have been realigned, a pop-up will be shown to warn you about the change. After **verifying the adjustments**, you can safely return to the home screen.



# 8.3 Set a New Reference Position

'Set reference position' allows you to define a reference position, different from the one you set during skill creation.

- 1 Tap on the **three-dot menu** on the right side of the skill overview as shown in the beginning of this chapter. Select 'Set reference position'.
- 2 **Guide the robot to the desired position** and tap 'Save Position'. This is the position the robot can be moved back to when starting to record new episodes or test skills. Then tap on 'Save Position'.



# 8.4 Deleting Skills

Tap on the three-dot menu on the right side of the respective skill card as shown below or on the right side of the skill overview. Select 'Delete Skill'.

#### ▲ Important

Once a skill is deleted, it cannot be recovered.

MIRAI   Skill Overview	<i>C</i>	MIRAI I Skill Overview	
	Add new skill +		Add new skill +
testskill Poetioning skil	1	test Psatoregisat	
	Camera settings		
0 episodes trained	Set reference position	S episodes trained Claudisana increases	Open
Mulfad Territo (ar 9) (51) - 660 annian (6	Denote and		
test Positioning skill	1		
		This will delive the soll and all associated data	
0 episodes trained	Open	8 episoder	Open
		Cancel	Delete
Modifed: Torby Sep 16:11 56 Skill venices: 0		United fold	
test	1	axis	
Transforming and		Method	
5 episodes trained Start cloud training	Open	1 episode trained	Open
Modified: Reachy Sec 13:16.04 Skill versions: 3		Qualities: In the $2\pi \times 2010$ . This remains the	
new		motion	
Positioning skill		Materian	
6 episodes trained Start cloud training	Open	1 egisode trained	Open

# 9 Shared Skills - Using a Skill on Different Setups

MIRAI controllers that belong to the same group will automatically share their skills with each other, allowing you to use the same skill on different setups.

#### i Note

To add a MIRAI Controller to your network, please contact a Micropsi Industries representative.

## 9.1 Preparing Your Physical Setup for Syncing

- To use a skill created on another MIRAI controller, you first need to synchronize that skill to your controller. This involves making sure that the hardware setup is suitable for the skill.
- To successfully 'sync' skills across MIRAI controllers or setups, consider the following:
  - Ensure that the applicable MIRAI controllers are added to your network.
  - **Ensure that your physical setup is complete and ready.** Use the following table as your guide. Nonetheless, the listed components on the table are also covered in the 'Skill synchronization' process detailed in the next section, 9.2 'Syncing a Skill to Your Setup'.

Physical Se	etup Components	Does it need to be <u>identical</u> across all Setups involved?	Recommendations / Tips for Your Physical Setup	Selection or Confirmation during the 'Skill synchronization' process in the MIRAI App
Robot Setup	Robot	Νο	To ensure a well-functioning skill, it is highly recommended to use the same robot model as the one on the original skill.	You can technically select any robot on the list provided by the app.
	Forque-torque Sensor	Νο	Ensure that the camera view is identical across setups. When syncing a skill trained with a F/T sensor to a setup without, special adjustments are necessary.	You can technically select any available F/T sensor or 'None'.
	Tool Center Point (TCP) Displacement	Yes	Ensure that the TCP displacement settings are matched. This is important as the end effector would rotate according to the original TCP displacement values set.	This cannot be modified in the app.
Camera: Physical Setup and Settings	Camera	Yes	Ensure that the camera model is the same. It is not recommended to sync a skill created on a USB camera setup to a setup with a GigE camera, or vice versa.	You should select the appropriate camera in the app.
	Number of Cameras Connected	Yes	Cannot be modified. Ensure that the correct number of cameras are connected.	This cannot be modified in the app.
	Camera Mount Setup	Yes	Cannot be modified. Ensure that how the cameras were mounted are the same (i.e., 'Wrist mounted' or 'Static mounted').	This cannot be modified in the app.
	Camera Lens	Yes	It is highly recommended to use the same camera lens to ensure it has the same focal point as on the other setup.	You do not need to confirm the lens used in the app.
	Aperture & Focus	No	These are physical settings found on the camera itself and affect all other skills within a setup. Be careful when changing these settings.	You do not need to enter the aperture and focus settings in the app.
	Gain & Exposure	No	What matters the most is that the live camera view and reference images shown on the app screen look as similar as possible.	You need to check if these need to be adjusted while going through the Syncing process on the app.
Tool Setup	End effector	Yes	Ensure that you use the same end effector.	You should select the appropriate tool in the app.
	Tool Mass & CoG Values	Yes*	* The values need to be similar; however, they may end up being slightly different.	* You need to go through the tool configuration process in the app separately. For more information on this, see section 3.2.1 'Tool configuration'.

# 9.2 Syncing a Skill to Your Setup

#### 🛕 Important

- ✓ The MIRAI controller you are syncing the skill to (i.e., the controller you are currently working with) must be connected to the Micropsi cloud server during the process. If the controller is not connected to the Micropsi cloud server, all the skills available in your network based on their last uploaded versions will still be shown; however, the 'Sync' button will be greyed out. For more information on why a cloud connection is needed, please refer to chapter 12 'Data FAQ'
- For the skill to demonstrate results as similar to the original setup as possible, it is very important to **check and enter the appropriate settings** on each of the steps to **replicate the original conditions**.
- Ensure that the **camera view is identical across setups**. When syncing a skill trained with an F/T sensor to a setup that does not use an F/T sensor, special adjustments are necessary.
- 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.
- Proceed with 'Skill synchronization'. This process will involve five major steps (detailed below). The MIRAI app will guide you through each step. To begin, tap 'Physical robot setup'. Then continue with the directions below until the last step.

MIRAI   Skill Overview	Co Test Skill Positioning 4 - Setup
Local skills All skills Add new skill + Last updated: 26.09.2023 - 16:27	Skill synchronization In order for MIRAI to best replicate the results from the original skill setup, adjust the following settings. © It will take about 10 minutes to complete.
Test Skill Motion Motion Skill Modified: 26.09.2023 – 0.402 Skill versions 01 Cloud episodes 5 Local episodes 5	Physical robot setup
Test Skill Positioning	Tool setup >
Positioning skill Modified: 2003/2022-0058 Skill versions 01 Cloud epidodes 5 Local epidodes 5 Cloud training in progress 1 hour and 15 minutes remaining	Skill information >
Test Skill MTP Multi-target positioning skill Beta Last doud training N/A Skill versions 0 Cloud episodes 0 Local episodes 0	Camera settings and alignment
	Reference position >
Test Skill Positioning 2 Postoning skill Last cloid training M/A. Skill versione 0 Cloud repletedes 0 Cloud repletedes 0	
	Finish

#### Physical Robot Setup:

* Select the robot brand and model you are using from the 'Robot' drop-down menu, then click
'Next'. Note: You can technically select any robot on the list; however, to ensure a well-functioning skill, it is **highly recommended to use the same robot model** as the one on the original setup.

- * Select the F/T sensor you are using from the 'Force/Torque sensor' drop-down menu, then click 'Next'. *Note:* It is **highly recommended to use the same F/T sensor** as the one on the original skill. If you use a different one, this may change the length of the stack with the end-effector.
- * Make sure that the **camera setup you are using is identical to what is indicated** on the screen (i.e., the settings on the original skill), such as how many cameras were used, and how the camera was mounted; click 'Next' to confirm (*Note:* You cannot modify these settings at this stage). As mentioned in the checklist above, the lens to be used should also be the same one as on the original skill.
- * Make sure your setup matches the Tool Center Point (TCP) displacement settings indicated (X, Y, and Z displacement values, and RX, RY, and RZ angular values) on the screen. This is important as the end effector would rotate according to the original TCP displacement values set. Click 'Done' to confirm and proceed Step 2 (*Note:* You cannot modify these settings at this stage).

Test Skill Positioning 4 - Setup	×	Test Skill Positioning 4 - Setup	×
Physical robot setup - Step 1/4		Physical robot setup - Step 2/4	
Select your robot:		Select your force torque sensor.	
Note: In order to run the skill safely and robustly on this setup, use the same components with which the skill was originally created, especially the same robot model.			
		OnRobot	~
UR5e	-	Force/Torque Sensor	
Robot			
Next	→	← Back	Next >

Test Skill Positioning 5 - Setup X	Test Skill Positioning 5 - Setup	×
Physical robot setup - Step 3/4	Physical robot setup - Step 4/4	
Ensure the camera setup is identical to the one on the robot where the skill was originally created.	Ensure your setup matches the following Tool Center Point (TCP) displacement setting	IS:
Dual camera Number of cameras in use on the robot setup	8 mm 0 mm 5 mm Position X Position Y Position Z	
Wrist mounted How are cameras mounted?	4 rad 0 rad 0 rad Orientation RX Orientation RY Orientation	RZ
← Back Next →	← Back	ne →

# 2 <u>Tool Setup:</u>

Select the tool from the 'Tool' drop-down menu (i.e., Gripper, Picker, or Plug), then click 'Done' to proceed to the next step.

Test Skill Positioning 5 - Setup	×
Tool Setup – Step 1/1	
Select an existing tool, or add a new one using the tool configuration process.	
	~
Tool	
Go to tool configuration	
C Back	ne →

#### Note

- Ensure that you use the same end effector.
- If you did not use a tool previously, it is recommended to go through the tool configuration process, found in section 3.2.1 'Tool configuration'.
- If the skill you selected to 'Sync' has no rotations, this step will be hidden.

### **3** Skill Information:

- * Confirm the type of skill (i.e., Positioning skill, Motion skill, or Multi-target Positioning skill) by clicking on 'Next' (*Note:* You cannot modify these settings at this stage).
- * Confirm the enabled axis transitions and the enabled axis rotations (i.e., x-axis, y-axis, z-axis) by clicking 'Done' (*Note:* You cannot modify these settings at this stage).

Test Skill Positioning 5 - Setup X	Test Skill Positioning 5 - Setup X
Skill Information – Step 1/2	Skill Information – Step 2/2
These settings cannot be changed after the skill has been created, so be sure to check that your current setup matches the one on which the skill was originally created.	These settings cannot be changed after the skill has been created, so be sure to check that your current setup matches the one on which the skill was originally created.
	X-AXIS, Y-AXIS, Z-AXIS Enabled axis translation
Positioning skill	
Type of skill	
	x-axis, y-axis, z-axis
	Enabled axis rotation
← Back	← Back Done →

(4) **Camera Settings and Alignment:** Depending on how many cameras your setup has, go through the three (3) steps listed below for **each** camera.

### i Note

For **GigE cameras** to appear in the drop-down menu, their IP address must be configured to the correct subnet and they must be selected in the network settings of the MIRAI Training App. You can find instructions on how to correctly configure the IP address of GigE cameras in the Robot Integration Guides.

Test Skill Positioning 5 - Setup	×
Camera settings and alignment	
Camera 01	>
Camera 02	>
e Back	Next →

- * Using the drop-down menu, select the camera that matches the reference image shown to you on the screen, then click 'Next'. (*Note:* The reference image shown comes from the original skill setup).
- * Guide the robot to align the live camera view with the reference image as precisely as possible. The sliders are meant to aid you with ensuring that the reference image and the live camera view image are as aligned as possible.
  - 'Reference image frequency' refers to how frequent the reference image would blink over the live camera view image. That said, you should drag the slider to the right side if you want the reference image to blink more frequently.
  - 'Reference image opacity' refers to how opaque the reference image overlay would be. Given this, you should drag the slider to the left side if you want the overlay to be minimal (i.e., more transparent).
- * Adjust your camera settings to match the reference image shown as closely as possible.
  - Please check the gain and exposure and if needed, adjust these via the sliders. What
    matters the most at this point is that the live camera view and reference images shown
    on the screen look as similar as possible. That said, if your current gain and exposure
    settings are not exactly the same as the one used on the original skill, it is recommended
    that you adjust them so that the images on the screen match as closely as possible.
  - Additionally, check the camera's focus and aperture (*Note:* These are physical settings found on the camera itself; they also affect all other skills, so please be very careful when changing these settings).
  - Tap 'Apply settings', and then 'Next' if you are content with the settings you have entered.





### **5** <u>Reference Position</u>

Guide the robot to the position that will be saved as the reference position. Tap 'Save position', and then 'Done'.



6 Once you have finished all the Skill synchronization steps, tap 'Finish'.

Test Skill Positioning 5 - Setup	×
Skill synchronization In order for MIRAI to best replicate the results from the original skill setup, adjust the following settings. © It will take about 10 minutes to complete.	
Physical robot setup	>
Tool setup	>
Skill information	>
Camera settings and alignment	>
Reference position	>
Finish	

The 'Details' screen will then show the information of the shared skill. You may select what to do next with the skill (e.g., 'Record episodes', 'Start cloud training', or 'Test & configure').



### 9.3 Recording Additional Episodes for Your Setup

Recording additional episodes for a shared skill would essentially be the same process as recording episodes for a newly created skill (see sections 4.1 to 4.2.3, depending on the type of skill you are training). Nonetheless, below are some tips in making a shared skill more robust:

- **Skill Type:** Ensure that when recording more episodes for the shared skill, it follows the recommended approach for the specific skill type (e.g., if it is a Positioning skill, move the robot in a spiral motion away from the target and scan all the relevant points in the space surrounding it as described in section 4.2.1 'Training a Positioning Skill').
- **Degrees of Freedom:** Ensure that when recording more episodes, you move in all the originally

enabled axis translations and rotations (e.g., if it is a z-axis rotation skill, make sure to record data showing rotations in the z-axis).

- **Reference Position:** This needs to be configured on every MIRAI Setup. Ensure that you define this when syncing (step 7 in the 'Skill synchronization' process).
- **End States:** This, too, needs to be configured on every MIRAI Setup. End states can be set within 'Execution Settings' inside the Testing loop (see section 7 'Setting End State Triggers').

#### i Note

In the Episodes tab, only episodes recorded on the MIRAI Controller you are currently working with can be seen. On the other hand, when you request a new skill version, **it will be trained on all the episodes** from all the MIRAI controllers within your network. See section 5.3 'MIRAI Cloud Training and Skill Versions' for more details on how to request a skill version.

# 10 Service Support

In the main menu (top left corner), select 'Service Support'.

Menu	×		
Skill Overview			
Network Configuration			Add new skill +
Tools			
Tag Management			
Service Support			
Backup and Restore			
			Add episode
			Add episode
		raining in progress inutes remaining	
			Test & configure skill
			Add episode
			Test & configure skill

### 10.1 Enabling Remote Access

The first section, 'Grant remote access', enables the MIRAI customer support team to access your controller for troubleshooting. **Enable this feature only when asked by our support staff**.

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Update	Update	Click on the button to download the	Intest version of the KIRAI Training App.
ираала	upaane		
		Update	

• Once the connection is successfully established, a blue bar appears on the top end of the screen to indicate that the remote access is active. A successful connection is indicated by the 'Under remote access' status bar. You can continue using the app while being connected to remote access.

• To disconnect, select 'Disconnect from remote access' in the same screen.



### 10.2 Enabling Remote Monitoring

App update

If a MIRAI skill does not execute properly after transferring it to the native controller (PolyScope for UR robots, Teach Pendant for FANUC), remote monitoring enables the Micropsi Industries customer support team to investigate the execution of this skill. **Enable this feature only when asked by our support staff.** 

ion of the MIRAL Training Ap

Allow remot	Disconnect remote access
Remote mon	itoring
This feature allows remote monitoring	: MIRAI customer support team to acquire diagnostic data from skill executions. Enabling does not restrict you from using the app.
Allow remot	te monitoring Disconnect from remote monitoring
MIRAI log file	2
This information is first-level troubles!	useful for the micropsi industries customer services team or your distribution partner for hooting.
Upload log t	file
Software ver	sion
Current MIRAI and	MINT software versions:
MIRAI version: 9.2	.1-16-g2e43966 - staging
MINT version: dev	
Software upo	late
Use a USB Drive wi	ith a newer version of MIRAI to update the MIRAI controller.
Update	
App update	to develop the location of the MPA1 Technics has
Click on the buttor	to download the latest version of the willow Training App.
Update	
Language	
	med language.
Select your prefe	

### To enable remote monitoring:

- 1 Tap on the "Allow remote monitoring" button.
- 2 Run the program on the native controller and wait until the end of the skill execution.
- 3 Connect the MIRAI controller to the internet (skip this step if you are already connected).
- 4 Wait for the "Upload in progress" sign to turn green on the MIRAI Training app.

E MIRAI   Skill Overview	E MIRAI I Skill Overview
Add new skill +	Add new skill +
skill telemetry motion skill :	skill telemetry motion skill :
episodes trained     Start cloud training     Test & configure skill	0 episodes trained Start cloud training Test 6 configure 8kII
Modified: Viednosdy Mar 301405 Skill Rendon 1	Modifiel Vibriteolog Mar 20 14:25 Skill Invasion 1

5 You may disconnect from the internet.

### i Note

For more details on the connection to the Micropsi cloud server and how Micropsi Industries handles recorded data please refer to chapter 12 'Data FAQ'.

Remote monitoring turns off automatically after 4 hours without further action needed from your side. Alternatively, you can disable it by tapping on the "Disconnect from remote monitoring" button.

part team to access your system. Enauling remore access uses not
Disconnect remote access
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Disconnect from remote monitoring
si industries customer services team or your distribution partner for first-
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ase_candidate
MIRAI to update the MIRAI controller.

### 10.3 Updating the MIRAI Controller Software

This section outlines the steps to update the software version on the MIRAI controller. Contact the Micropsi Industries service team to obtain the latest software release.

### 🛕 Important

During the update process, ensure that the MIRAI controller can connect to the following hosts:

- https://apt.tools.micropsi.io (TCP Port 443)
- http://deb.debian.org (TCP Port 80)
- http://security.debian.org (TCP Port 80)

### Step 1: Prepare a USB drive

#### a. Obtain a USB Drive:

• Use a USB drive formatted with FAT32 (ideally 16GB or larger).

#### **b.** Prepare the software update:

- Download the software file from the link provided by Micropsi Industries.
- Copy the software file to the USB drive, saving it in the root directory.

#### Step 2: Back up your skills

### a. Enter the update loop:

- Turn on the MIRAI controller and wait for the second beep, signaling that the system is ready.
- $\circ~$  In the main menu of the MIRAI Training App, tap Service Support.
- Under the heading "Software update," tap Update.
- When prompted, insert the USB drive with the update file into the USB port of the MIRAI controller.
- Tap **Next** to proceed to the next screen.

NOTE: To leave the update loop, tap the **x** button in the upper-right corner. When prompted, tap **Yes, leave**.



#### b. Create a backup file

• Enter a name for your skill backup file and tap **Create backup**.

A green "Backup created" message will appear and the **Next** button will be activated. • Tap **Next** to proceed.

stem update process	×	System update process	
Create a backup - Step 2/5		Create a backup - Step 2/5	
		Before updating the box, please make sure to create a backup of the	e current skills.
rore updating the box, please make sure to create a backup of the current skills. The backup will be saved on the USB drive you have pluceed in the MIRAL controller box.		The backup will be saved on the USB drive you have plugged in the f	dIRAI controller box.
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Sth			
		Create backup Sackup created	
Create backup			

#### Step 3: Update the MIRAI controller software

**a**. : To facilitate support, tap **Allow remote access** and grant access to: mirai-vpn.micropsi-industries.com (UDP Port 1194).

rstem update process	×	System update process	
Allow remote access - Step 3/5		Allow remote access - Step 3/5	
To better assist you through the update process we suggest to establish a secure o VIRAI for the duration of the update process, to be able to assist in case of possible	connection with le failures.	To better assist you through the update process we suggest to est MIRALFor the duration of the update process, to be able to assist a	abilish a secure co case of possible
The following conditions must be met before a remote connection can be established.  • MRAI controlle box must have an active intermet connection.  • The network finewal must allow remote access.		The following conditions must be met before anomate connector can MRM: controller bia must have an allerer is there done to an • The network financi must date connecto screes.	oo eerabi shee
Allow remote access		Allow remote access	
		Remote access settings	
		The network linewall must have the following set • host: minal-yper, micropsi-industries.com • port: 1194 • preced.upp	ings enabled:
		- another, consolved	

**b**. On the next screen, tap **Update MIRAI controller**. After installation, a green message will appear saying "MIRAI controller update installed" and the **Next** button will be activated.

stem update process	× System update process	
tart the update - Step 4/5 Odate details RAI veloci: 2021:0527180816 Frenseast 2021:0527180816 portant: Please make sure that during the whole process, the MIRAI controller is not switch	Start the update - Step 4/5           Update details           MRA version: 2021 65/27 180816           Date relevance 2021 65/27 180816           Important: Please make sure that during the whole pu off.	ocess, the MIRAI controller is not switched
Update MIRAI controller	Update MIRAI controller SMIRAI control	er update installed
← Back Next	→	

### Step 4: Download the latest version of the MIRAI Training App

- a. Tap **Download MIRAI Training App** to save the current version of the MIRAI Training App to your tablet.
- **b**. Proceed to the next section, 10.4 Updating the MIRAI Training App.

ystem update process		×
Update the M	IRAI Training App - Step 5,	/5
ompatibility issues wit	p version is available. Please download and ins installed software.	tall the latest version to avoid
The steps to install the Download it with the b Close the current MiR Install the downloades Open the updated MiR	pdated MIRAI Training app are the following: uton below. I Training app app (it is an .apk file). Ni Training app.	
	Download MIRAI Training App	

### i Note

If you need to update the MIRAI software package for your robot platform, an additional link will be included in the email with the controller update.

### 10.4 Updating the MIRAI Training App

### **A** Important

Uninstall the current MIRAI Training App on your tablet *before* reinstalling the latest version from the MIRAI controller.

### Download the app:

If you need to download the latest version of the MIRAI Training App, go to the app's main menu and tap **Service Support**. Under the heading "App Update," tap **Update**. This will start the internet browser on the tablet and open <a href="http://mirai:6543/mint/apk">http://mirai:6543/mint/apk</a>. Click to confirm downloading the MIRAI Training App installation file, mint.apk. After downloading, tap on the file in the Android file browser to install the app. If a security message requests permission to install the APK file, grant the request.

=	MIRAI   Service Support
	Allow remote monitoring
M Tř fir	IIRAI log file in information is useful for the micropsi industries customer services team or your distribution partier for the of southeatcooling. Upboad log file
S	oftware version
CL	irrent MIRAI and MINT software versions:
м	RAI version: 17.0.1-15-g7db163f - ranewgeometry-feature
м	RAI Training App version: 0.1.33
S	oftware update
	Update
Ν	IIRAI network interface
м	AC address: 00:01:2e:a8:b6:a4
A	pp update
Та	p the button to download the latest version of the MIRAI Training App.
	Update
Li	anguage
Se	ect your preferred language.
	inglish  V Apply settings

### Uninstall the current version of the app:

Refer to the instructions for your tablet. Apps on Android-based tablets can generally be uninstalled by tapping and holding the app until a menu with "Uninstall" appears.

#### Install the latest version of the app:

Locate and tap the APK file you previously downloaded to install it. Then open the new version of the app.

### 10.5 Log Files

### Uploading Log Files

The log files are required in case of first level troubleshooting. Tap the button if this is requested by your distribution partners or the Micropsi Industries customer support team. The file will be uploaded onto the secure premises of the Micropsi cloud server.

Remote access	
Grant our customer suppo used as normal if access h	rt team access to troubleshoot your system remotely. The app can still be as been granted.
Grant remote acces	15
Remote monitoring	
Allow our customer suppor app can still be used as no	rt team to remotely monitor skill executions for a period of 4 hours. The rmal during this time.
Allow remote monit	toring
MIRAI log file	
This information is useful f partner for first-level troubl	for the micropsi industries customer services team or your distribution leshooting.
Upload log file	Show log file
Software version	
Current MIRAI and MINT se	oftware versions:
MIRAI version: 00.01.2e:a0.93 MIRAI Training App version: 0	35 0.01:2ea0.93.35
Software update	
Use a USB Drive with a nev	ver version of MIRAI to update the MIRAI controller.
Update	

### Show Log Files

Tap the "Show log file" button to show the last 1000 lines of the most recent log file.

MIRAL   Service Support	← Show log file
Remote access	<idoctype html=""><html lang="en"><head><script>(function(w,d,s,l,i)(w[l]=w[l]))</td></tr><tr><td></td><td>[];w[l].push({'gtm.start':new Date().getTime(),event:'gtm.js'});var f=d.getElementsByTagName(s)</td></tr><tr><td></td><td>[0],j=d.createElement(s),dl=l!='dataLayer'?&l='+l.";j.async=true;j.src='https://</td></tr><tr><td>Grant our customer support team access to troubleshoot your system remotely. The app can still be</td><td>www.googletagmanager.com/gtm.js?id='+i+dlf.parentNode.insertBefore(j,f);})</td></tr><tr><td>used as normal if access has been granted.</td><td>(window,document;script;dataLayer;GTM-TFD/QTG);</script><link +i+dlf.parentnode.insertbefore(i="" async="true'i" ft:3)<="" href="https://&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Crant remote access&lt;/td&gt;&lt;td&gt;micropsi-industries.com/index-de.ntml inrefiang= de-DE &gt;&lt;link rei= alternate inref= https://microp&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Glair lenote access&lt;/td&gt;&lt;td&gt;industries.com/index.ntml inreliang= en-US &gt;&lt;meta charset= uti-8 &gt;&lt;meta name= revisit-arter&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;content= 14 days &gt;&lt;meta name= geo.region content= Benin &gt;&lt;meta name= geo.piacename&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;content= Benin &gt;&lt;meta name= viewport_content= width=device-width, height=device-height, initia&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Remote monitoring&lt;/td&gt;&lt;td&gt;scale=1.0, user-scalable=0, minimumscale=1.0, maximumscale=1.0 / simk&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;SUDGET FE Transmithining = en &lt;neau&lt;script=(ranction(w,u,s,u)(w(i)=w(i))&lt;br&gt;Inviti nuch(/atm start:new Data() astTima() event:'atm is'\):var f=d astElementeBvTagNama(s)&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Allow our customer support team to remotely monitor skill executions for a period of 4 bours. The&lt;/td&gt;&lt;td&gt;[0] i=d createElement(s) di=li='datal aver'?&amp;l='+!" i="" rel="alternate" src="https://&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;ann can still be used as normal during this time&lt;/td&gt;&lt;td&gt;www.googletagmanager.com/otm is?id=" td=""/></head></html></idoctype>
upp can suit be abea as non nar during this time.	(window document/script/'datal aver/'GTM-TED70TG'): <link href="https://&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Allow remote monitoring&lt;/td&gt;&lt;td&gt;micropsi-industries.com/index-de.html" hreflang="de-DE" rel="alternate"/> <link href="https://microp&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;industries.com/index.html' hreflang='en-US'&gt;&lt;meta charset=" rel="alternate" utf-8"=""/> <meta <="" name="revisit-after" td=""/>
	content="14 days"> <meta content="Berlin" name="geo.region"/> <meta <="" name="geo.placename" td=""/>
	content="Berlin"> <meta content="width=device-width, height=device-height, initia&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;MIRAI log file&lt;/td&gt;&lt;td&gt;scale=1.0, user-scalable=0, minimum-scale=1.0, maximum-scale=1.0'&gt;&lt;link&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;&lt;!DOCTYPE html&gt;&lt;html lang=" en"="" name="viewport"/> <head><script>(function(w,d,s,l,i){w[i]=w[i]  </td></tr><tr><td>This information is useful for the micropsi industries customer services team or your distribution</td><td>[];w[l].push({'gtm.start':new Date().getTime(),event.'gtm.js'});var f=d.getElementsByTagName(s)</td></tr><tr><td>partner for first-level troubleshooting.</td><td>[0],j=d.createElement(s),dl=l!='dataLayer'?'&l='+l.";j.async=true;j.src='https://</td></tr><tr><td></td><td>www.googletagmanager.com/gtm.js?id='+i+dl;f.parentNode.insertBefore(j,f);})</td></tr><tr><td>Unlead law file</td><td>(window,document;script;'dataLayer';GTM-TFD7QTG');</script><link href="https://&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Show log ne&lt;/td&gt;&lt;td&gt;micropsi-industries.com/index-de.html" hreflang="de-DE" rel="alternate"/><link href="https://microp&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;industries.com/index.html' hreflang='en-US'&gt;&lt;meta charset=" rel="alternate" utf-8"=""/><meta <="" name="revisit-after" td=""/></head>
	content="14 days"> <meta content="Berlin" name="geo.region"/> <meta <="" name="geo.placename" td=""/>
Software version	content="Berlin"> <meta alternate"="" content="width=device-width, height=device-height, initia&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Soltware version&lt;/td&gt;&lt;td&gt;scale=1.0, user-scalable=0, minimum-scale=1.0, maximum-scale=1.0'&gt;&lt;link&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;&lt;iDOC   YPE html&gt;&lt;ntmlang= en &gt;&lt;nead&gt;&lt;script&gt;(lunction(w,d,s,t,l)(w[i]=w[i])&lt;br&gt;[built] buok((atm_startionuv_Date() actTime() substitute is?)) use find actElementeDuTechlame(a)&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;Current MIRAI and MINT software versions:&lt;/td&gt;&lt;td&gt;[],w[],push((gth).start.new Date().get http://gth.gth.gth.gth.gth.gth.gth.gth.gth.gth.&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;MIRAI version: 00:01:2e:a0.93:35&lt;/td&gt;&lt;td&gt;[0], J-0. Created enterin(s), di-it-datadayer ? ai-+1. J. async-it dej. sic-nit.ps.//&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;MIRAI Training App version: 00:01:2e:a0.93:35&lt;/td&gt;&lt;td&gt;(window document'script'/datal.aver/'GTM-TED70TG'):&lt;/script&gt;&lt;link rel=" href="https://&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;micropsi-industries.com/index-de.html" hreflang="de-DE" name="viewport"/> <link href="https://micror&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;industries.com/index.html' hreflang='en-US'&gt;&lt;meta.charset=" rel="alternate" utf-8"=""/> <meta.name="revisit-after"< td=""></meta.name="revisit-after"<>
Software undate	content="14 days"> <meta content="Berlin" name="geo.region"/> <meta <="" name="geo.placename" td=""/>
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	www.googletagmanager.com/gtm.js?id='+i+dl;f.parentNode.insertBefore(j,f);})
	(window,document/script'/dataLayer'/GTM-TFD7QTG'); <link href="https://&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;&lt;/td&gt;&lt;td&gt;micropsi-industries.com/index-de.html" hreflang="de-DE" rel="alternate"/> <link href="https://microp&lt;/td&gt;&lt;/tr&gt;&lt;tr&gt;&lt;td&gt;MIRAI network interface&lt;/td&gt;&lt;td&gt;industries.com/index.html" hreflang="en-US" rel="alternate"/> <meta charset="utf-8"/> <meta <="" name="revisit-after" td=""/>
	content="14 days"> <meta content="Berlin" name="geo.region"/> <meta <="" name="geo.placename" td=""/>

### 10.6 Software Version

The version number of the MIRAI software and the training app are listed under 'Software Version'. This information can be relevant in case of software updates and when reaching out to Micropsi Industries customer support.

MIRAI   Service Support
Allow remote monitoring Disconnect from remote monitoring
MIRAI log file This information is useful for the micropal industries customer services team or your distribution partner for Each and insultationations Upstead log file
Software version Current MIXAI and MIXT untheway versions: MIXAI version: 72.01159/2016131-rate-waysconetry-feature MIXAI Training Approxematio. 0.1.33
Software update Use a USB Drive with a never version of MIRAI to update the MIRAI controller. Update Update
MIRAI network interface MACadress: 00012ca836ca4
App update To the botton to download the latest version of the MIRAI Training App. Update
Language Select your preferred language.

### 10.7 MAC Address

MIRAI's MAC Address can be found under 'MIRAI Network Interface'.

=	MIRAI   Service Support
	Allow remote monitoring
M Th firs	IRAI log file Is information is useful for the micropsi industries customer services team or your distribution partner for Here Broadbehooting.
	Upload log file
Sc	oftware version
Cu	ment MIRAI and MINT software versions:
мі	RAI version: 17.0.1-15-g7db163f - ranewgeometry-feature
MI	RAI Training App version: 0.1.33
Sc	oftware update
Us	e a USB Drive with a newer version of MIRAI to update the MIRAI controller.
Us	e a USB Drive with a newer version of MIRAI to update the MIRAI controller.
Us	e a USB Drive with a newer version of MIRAI to update the MIRAI controller.
05	a USB Drive with a newer version of MIRAI to update the MIRAI controller. Update
Us M	a USB Drive with a newer version of MIRAI to update the MIRAI controller.
Us M	a USB Drive with a newer version of MIRAI to update the MIRAI controller. Update IRAI network interface C address: 00.012a:a8b:6:a4
Us M	a USB Dries with a newer version of MIRAI to update the MIRAI controller: Update IRAI network interface C address: 00.01.32 add 66.4
Us M M/	La USB Drine with a newer version of MIRAI to update the MIRAI controller. Update IRAI network interface Caldeess: 00:01:2ea8366a4 pp update
Us M M Ap Tap	ta USB Drive with a newer version of MIRAI to update the MIRAI controller. Update RRAI network interface C address: 00:01:02:a3b6:a4 bp update the button to download the latest version of the MIRAI Training App.
Us M Al Taj	a USB Drive with a newer version of MIRAI to update the MIRAI controller: Update IRAI network interface C advess: 00:12:a:ab:6:a4 Dop update Update Update
M M A Tap	a USB Drive with a newer version of MIRAI to update the MIRAI controller. Update IRAI network interface C address: 00:012 exit bits a4 Drip Update Update
M M Ap Tap	Le USB Office with a newer version of MIRAI to update the MIRAI controller. Update IRAI network interface C address: 00:01:2ea8b6:a4 Sp update Update Update
Us M M A I Taj	a USB Drive with a newer version of MIRAI to update the MIRAI controller: Update IRAI network interface C adverse: 00:13:2a:bb:64 C adverse: 00:13:2a:bb:64 IRAI retwork interface IRAI network interface IRAI
Us M M Taj La Se	a USB Drive with a newer version of MIRAI to update the MIRAI controller.  Vpdate  RAI network interface (c adverse: 00:01:2:aa1:bisa1  pp update bite butten to download the latest version of the MIRAI Training Age.  Update  inguage lict your preferred language.
M M A I Taj	a USB Drive with a newer version of MIRAI to update the MIRAI controller: Update RRAI network interface C adverse: 000112-call bit ad Dipupdate Dipupdate Dipupdate Extra Dipupdate Restors: referred language. Extra Dipupdate Diputed Dipute

## 10.8 Language Settings

Click on the language dropdown menu to choose your preferred language setting. You can choose between English and German.

	Allow remote monitoring Disconnect from remote monitoring
MI	RAI log file
Thi first	s information is useful for the micropsi industries customer services team or your distribution partner for level troubleshooting.
	Upload log file
So	ftware version
Cur	rent MIRAI and MINT software versions:
MIF	IAI version: 17.0.1-15-g7db163f - ranewgeometry-feature
MIF	Al Training App version: 0.1.33
So	ftware update
Use	a USB Drive with a newer version of MIRAI to update the MIRAI controller.
	Undere
	opuare
MI	RAI network interface
MA	C address: 00:01:2e:a8:b6:a4
Ap	p update
Тар	the button to download the latest version of the MIRAI Training App.
	ladate
La	nguage
Sel	ect your preferred language.
E	nglish V Apply settings

## 11 Backup and Restore

### 11.1 Creating a Backup of MIRAI Skills

### i Note

Please use a USB drive and format it with FAT32 (16GB and larger).

1 To create a backup of your existing MIRAI skills, on the main menu (top left corner) select 'Backup'.



- 2 Insert a USB stick (minimum 16GB) into one of the USB ports located on the MIRAI controller.
- $^{(3)}$  Enter a name for the backup file and then select 'Create backup'.

Create Backup	Restore Backup
Backup all current skills on the MIRAI controller	to a USB drive.
Sackup name (max. of 80 characters)	
Create backup	

⁽⁴⁾ This process will take a few minutes. Do not switch off the MIRAI controller or the tablet during this process. Also refrain from removing the USB stick as long as the backup is ongoing. Once the

backup is successfully created, the message below will be displayed. Tap on 'Done'.



### 11.2 Restoring MIRAI Skills into the MIRAI Controller

This feature allows you to restore the saved skills back to on the MIRAI controller.

### A Important

This process **will replace the current skills** with the state of the backup and with that delete all changes done since the last backup. Please make sure to back up your skills again after a MIRAI software update.

1 To restore a backup of skills, insert a USB stick into one of the USB ports located on the MIRAI controller. From the main menu, select 'Backup', and then select the 'Restore Backup' tab.

2 From the displayed list of backups, tap on 'Restore' for restoring the relevant backup.

E MIRAI   Backup		MIRAI   Backup		
Create Backup	Restore Backup	Create Bac	kup Restore Ba	ckup
Backup all current skills on the MIRAI controller to	a USB drive.	Restoring a backup will recor- box, and delete everything or	ver all the skills. Note that this will overwrite the the box.	current state
Backup name (max. of 80 characters)		Backup name	Timestamp	
		backup 1	Wednesday Jun 03 09:52 2020	Rest
Create backup		backup 2	Wednesday Jun 03 09:52 2020	Rest

③ Once the process is complete, the MIRAI controller will reboot after which the restored skills will be seen on the main screen.

### i Note

Do not switch off the MIRAI controller or the tablet during this process. Also refrain from removing the USB stick until the restore is successfully completed.

MIRAI   Backup			MIRAI   Backup		
Create Backup	Restore Backup		Create Backup	Restore Back	up
Restoring a backup will recover all box, and delete everything on the b	the skills. Note that this will overwrite the current sta xxx.	ate of the E	Restoring a backup will recover all t box, and delete overything on the b	he skills. Note that this will overwrite the cur ox.	rent state of the
Backup name	Timestamp		Backup name	Timestamp	
backup 1	Wednesday Jun 03 09:52 2020	estore	backup 1	Wednesday Jun 03 09:52 2020	Restore
backup 2 Preses well and the rebective La done: set back to the back	•boting -booting process is firsted. When the window will disappear and your box is orup you've elected.		Sackup 2 Sackup Rackup backup	p successfully restored 1 has been restored. Done	Resor

# 12 Data FAQ

The following questions focus on how Micropsi Industries handles data recorded by MIRAI.

### What types of data does Micropsi Industries collect and store?

The MIRAI robot control software uses sensor data to enable robots to act in settings with high production variances. When a user creates a robot skill with MIRAI, the initial skill configuration entered into the MIRAI Training App is stored.

Further data is collected when a user starts recording episodes during the MIRAI training phase. The MIRAI system collects and stores the following data types:

- camera image data (camera typically attached to the robot's wrist)
- robot motion data
- Force/Torque sensor signals
- tool center point (TCP) positions
- software version
- skill meta data (skill type, skill name, degrees of freedom, action frame)
- log files / diagnostic data

No data is collected and stored during skill execution / unsupervised production operation, with the exception of rotating logs - which means older logs are overwritten by newer logs.

Note that the videos provided typically do not show human workers or even complete wokspaces. These are very zoomed-in sequences taken by cameras typically moving with the robot, showing the robot's end-effector and/or an individual part.

Data is only ever stored on the MIRAI controller (indefinetly) and on the Micropsi cloud server (indefinity). The training app is a pure user interface to the MIRAI controller and does not persist any data except the IP address of the controller to talk to.

### What does Micropsi Industries use that data for?

Micropsi Industries uses data described above to prepare and/or train skills – mathematical models that generate actions the robot executes. A skill connects the raw sensor information captured by the camera and the Force/Torque sensor to the actions performed by the robot.

Beyond creating skills, Micropsi Industries does back-testing on existing data when new features are developed. This involves generating data sets, mixing anonymized data from multiple sources, and other machine-learning research in order to further improve models and algorithms. Skills will not be shared with third parties.

Furthermore, we store log file/diagnostic data to be able to help users in case of support requests. In order to create an initial password and Controller ID, the MIRAI controller will be provisioned with the customer's company name. The resulting Controller ID is needed to be able to provide remote support.

### Why ist the data not deleted after skill creation?

Whenever skills are modified with additional data, i.e. to make a skill more robust against a rare type of variance that wasn't encountered in initial training, the new skill version will be trained on all data available for that skill. That means that there is a functional requirement to keep training data available for future use in the cloud application.

Additionally, Micropsi Industries reserves the right to use the data for the purposes defined in Section 2. Requirements to delete data after a fixed period of time or on request can be discussed as part of a commercial discussion between Micropsi Industries and customers.

### Where is collected data stored and secured?

For data storage, Micropsi Industries uses AWS. The stored data is geographically located in the AWS eu-central-1 region, in Frankfurt, Germany. AWS uses triple redundancy, with no redundancy of data outside of eu-central-1. The data that MIRAI collects is S3 encrypted in transit and at rest (prior to January 5, 2023 HTTPS transport encrypted). A further encryption on storage level is not necessary, because read and decryption permissions would be in the same security realm. Whoever has reading access to the data, would also have access to the decryption key. Addendum All AWS users globally can rely on the terms of the AWS GDPR DPA which will apply automatically from May 25, 2018, whenever AWS services are used to process personal data under the GDPR. Please find the complete Data Processing (DPA) here: AWS Data Processing Addendum

Note however that MIRAI data as described above does not fall under the provisions of the GDPR, as it is not personal data as defined by the GDPR.

### Who has access to data on the Micropsi cloud server?

There are three groups of Micropsi Industries employees that need access to user data in the context of their work. The three roles are developers, reviewers & admins.

- developers can list files (while not seeing the content) when debugging or updating the server-side cloud / data- processing application
- reviewers can read files incl. content in order to debug and optimize skill performance. This role is intended for support staff, mainly machine learning and application engineers
- admins can write & delete files incl. content in order to ensure overall functionality

Access will be granted for valid reasons and on individual level. Only admins can grant access and individual access keys can be revoked anytime. Permissions & access rights are documented and regularly reviewed.

No customer users can access the data stored on the Micropsi cloud server, it's used solely by the cloud application to create skills that will be downloaded to the MIRAI controller.

### Note

Above mentioned access refers only to data on the Micropsi cloud server. Micropsi Industries does not have access to a MIRAI system in operational mode.

### Why does MIRAI need a cloud?

The heavy lifting for creating a MIRAI skill from recorded data requires very powerful hardware. Delivering this hardware in the MIRAI controller would make the controller extremely expensive, especially considering that 99% of the time, MIRAI controllers do something else. It's just reasonable to share the resources for these brief bursts of computation between MIRAI installations.

In addition, access to the data recorded by MIRAI installations (see the other answers for what we do with the data) is important for Micropsi Industries' ability to deliver a superior product. We're a specialist for turning this data into value for our customers, and access to data enables us to do this.

### Why is the cloud not on Micropsi Industries' own hardware?

There are no advantages of operating our own data centers, or operating our own server hardware in a data center that is not AWS'es. AWS has excellent service levels, superior security to anything we could provide at comparable cost, and enough capacity reserves to allow us to service the compute needs of our MIRAI installations even if they all decide to create a skill at the same time.

Renting compute capacity and services around security and availability while retaining full control of the data used for the computation is the de-facto default model for all sensibly run IT today.

### Can I operate MIRAI on my own corporate cloud?

In general, no. Micropsi Industries would consider such a scenario only for deployments of >100 MIRAI units. The Micropsi Industries server-side infrastructure is a complex application, requiring multiple specialized containers to run, as well as GPU-enabled resources ready to spin up on request. Operating, updating and maintaining such an application in a shared responsibility with a corporate IT unit introduces several severe friction lines and requires large operational efforts on Micropsi Industries's side. Engaging in any form of shared-responsibility application hosting (containerized or not) requires a serious-long-term commitment of both parties. Usually, when such long-term commitments are commercially and strategically an option at all, the matter of hardware operation and security/availability service outsourcing is not a relevant factor and a commercially equivalent contractual alternative can be found to moving applications around physically.

### What networks are included in the standard MIRAI setup?



#### Most customers implement a variant of this network architecture:

Figure 10: GigE single camera setup

There are three networks in the standard MIRAI setup: the robot network, the WAN, and the Wi-Fi network. The MIRAI controller uses different ports for each network, ensuring they remain separated and cannot communicate with each other.

1. **Robot Network:** This network includes the MIRAI controller, the robot controller, a force/torque sensor (if used), and the GigE camera or cameras (if used). Each device in this network has a static

IP address. The devices are connected through specific ports on the controller, ensuring they operate within an isolated network that cannot communicate with the other networks.

- 2. WAN Network: This network also includes the controller, but it is connected through a different port preconfigured to expect a DHCP-assigned IP address. The WAN typically includes an HTTP/HTTPS proxy that facilitates communication between the controller and the Micropsi cloud, making it reachable via the internet. This network is logically separated from the robot network.
- 3. **Wi-Fi Network:**This network is created by the controller and includes a single member, an Androidbased tablet. The Wi-Fi network is isolated from both the robot network and the WAN, ensuring that the tablet can only communicate with the controller through this dedicated wireless connection.

### Can the connection to the Micropsi cloud server go through an HTTP proxy?

Yes. A proxy for the connection to the Micropsi cloud server can be configured via the tablet app's "Network configuration" section. The proxy needs to allow connections to the following hosts:

For training: https://crunch.micropsi-industries.com (TCP Port 443) https://crunch.micropsi.io (TCP Port 443) For support: mirai-vpn.micropsi-industries.com (UDP Port 1194) For software updates: https://apt.tools.micropsi.io (TCP Port 443) http://deb.debian.org (TCP Port 80) http://security.debian.org (TCP Port 80)

# Does Micropsi Industries require any form of remote access into their customer's networks?

No. There is a VPN-based remote-access facility available, but its use is not mandatory. It is disabled by default, defaults to disabled on boot, and should only ever be turned on during a remote support scenario and discussed with Micropsi Industries support. Customers that prefer not to allow VPN connections into their networks for remote service of an edge device can provide alternative ways of giving remote access, i.e. SSH sessions from Citrix terminals.

# How is access control handled for the Micropsi cloud server, MIRAI controller, and training app?

The cloud application has no user-facing interfaces. Its only interfaces are machine-to-machine APIs that are being used by the MIRAI controller.

MIRAI controllers authenticate against the cloud services with their ID and a secret token generated at provisioning time. Customers cannot access these tokens (seeing them requires SSH access to the MIRAI controller, which customers don't typically need/have).

The training app and the MIRAI controller's APIs that it uses are assumed to be in a safe network (i.e. part of a machine and connected to a robot) and do not require authentication.

# 13 Document Version Details

Document Version	Software Version	Date	Updates & Additions
1	Jove 10.0.0	27.01.23	User Guide has been separated into two parts: Part 1: Robot Platform Integration Part 2: MIRAI Training App Guide Section 3.3 Skill Versions Section 4.5.1 Camera Settings Section 5.1.4 Updating App Minimum exposure limit is increased to 100
2	Lili 11.0.0	17.07.23	Section 1.5 Recording Multi-target Positioning Skills Section 2.1 Adding a Skill in the Training App: TCP displacement Section 3.1.1 Training a Positioning Skill: Before Recording an Episode: Camera grid feature Section 3.2 Training a Multi-target Positioning Skill New chapter Section 5.7 MAC Address MAC Address information updated
3	Mercury 12.0.5	04.10.23	Chapter 5 Shared Skills – Using a Skill on Different Setups New chapter
4	13.1.1	28.11.23	Section 3.2.1 FANUC CoG Estimation
5	14.3.2	18.12.23	<ul> <li>Chapter 1 Safety Precautions New chapter The chapter numbers in this user manual version have been updated given the addition of Chapter 1. What was previously Chapter 1 is now Chapter 2, and so forth.</li> <li>Chapter 4 The Training Loop – Recording Episodes 4.1 Training without a F/T Sensor 4.1.1.2 Recording Episodes Using the Recording Assistant (Beta) 4.2 Training with a F/T Sensor 4.2.1.2 Recording Episodes Using the Recording Assistant (Beta) 4.2.1.4 Training Tips</li> <li>Chapter 5 Testing, Refining, and Embedding MIRAI Skills 5.3 Troubleshooting Positioning Skills 5.4 Troubleshooting Motion Skills</li> </ul>
6	16.0.0	18.03.24	Section 5.4 Setting End State Triggers Proximity-based and Anomaly-based end states added
7	16.1.0	30.04.24	<ul> <li>Chapter 4 The Training Loop         <ul> <li>Former chapter 10 Best Practices was                 integrated into chapter 4 (Sources of Variances,                 Training Tips)</li> </ul> </li> <li>Chapter 5 Testing, Refining, and Embedding         <ul> <li>Former chapter 9 Implementing MIRAI Skills into                 the Robot Program is now a section in this                 chapter</li> <li>Chapter 6 Setting End State Triggers                 This section was a part of chapter 5 before, now                 has its own chapter</li> </ul> </li> </ul>
8	18.0.0	23.05.24	Section 4.1.1.2.1 (and 4.2.1.2.1) Setting up the Recording Assistant Step 3 'Adjust Motion Settings' was added

9	19.1.1	15.10.24	Chapter 11 Data FAQ New chapter
10	20.0.0	31.10.24	Chapter 5 Reviewing & Cloud Training New chapter New section 5.1 Target Frame Review Sections 5.2, 5.3 and 5.4, originally from chapter 4, were moved here

# 14 Declaration of Incorporation

### **MICROPSI INDUSTRIES**

EU Declaration of Incorporation (in accordance with Machinery Directive 2006/42/EC Annex II, part B)

Manufacturer:	Person Authorized to Compile the Technical File:				
micropsi industries GmbH	Naaimah Saghir				
10963 Berlin, GFRMANY	micropsi industries				
Description and Identification of the Partly Completed Machine(s)					
Product and Function:	sion-based motion control system for industrial robot systems that enables				
	ich robot systems to solve automation problems with high variance in				
	position, shape, or background and lighting conditions. The final function is				
	application with intended use).				
Model:	RAI				
	ftware version 14.0.0 onwards				
Incorporation:	e MIRAI vision-based motion control system shall only be put into operation on being integrated into a final completed machine, which conforms with e provisions of the Machinery Directive and other applicable directives.				
It is declared that the above product, for what is supplied, fulfils the directives as detailed below: When this partly completed machinery is integrated and becomes a final machinery, the integrator is responsible for determining that the final machinery fulfils all applicable Directives and providing the Declaration of Conformity.					
(I) Machinery Directive	The following essential health and safety requirements were fulfilled:				
2006/42/EC	Annex IV, clause 1.1.2, 1.1.3, 1.1.5, 1.2.2, 1.2.3, 1.5.1, 1.5.2, 1.7.1, 1.7.2, 1 7 4				
	It is declared that the relevant technical documentation was compiled in				
	accordance with Annex VII, Part B				
	The following Harmonized Standard were used (where applicable): EN 60204-1:2019				
(II) Low-Voltage Directive 2014/35/EU	The following Harmonized Standard were used (where applicable): EN IEC 60320-1:2023				
	The following standards were used:				
	Article 3.1a): EN60950-1:2006+A11:2009+A1:2010				
(III) Radio Equipment Directiv	Article 3.1b): Draft EN 301 489-1 V2.2.0; final draft EN 301 489-3 V2.1.1;				
2014/53/EU	Draft EN 301 489-17 V3.2.0				
	Article 3.2): EN 300 328 V2.1.1; ETSI EN 301 893 V2.1.1; ETSI EN 300 440 V2.2.1				
(IV) Other directives	All applicable directives and harmonized standards have been followed				
	by the component suppliers and can be provided upon request.				
Reference to Uther Technical Standards and Specifications Used:					
EN ISU TUZT8-2:2011, ISU/TS 15066:2016 The manufactures of his authorized representative, shall transmit relevant information about the partly					
completed machinery in response to a reasoned request by the national authorities.					
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Berlin, Germany, 15 February 2024

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Ronnie Vuine, Chief Product Officer

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