

Operato Robotics

User Guide V.0.21

Docker-based Installation

- Download and run the installation script
 - `curl -fsSL https://raw.githubusercontent.com/things-factory/things-factory/master/packages/operato-robotics/installer/install.sh | bash -s`
- Run docker containers of operato-robotics
 - `start.sh`
- Stop the running containers
 - `stop.sh`
- Run the migrate script after running 'start.sh', if you run operato-robotics dockers first after installation
 - `migrate.sh`
 - If migration finished, restart containers using 'stop.sh' and 'start.sh'
- URL & Login
 - <http://localhost:4000>
 - Login Info: `adim@hatiolab.com/admin`

Operato Basic Tutorials

Tutorial Video

<https://www.youtube.com/playlist?list=PLrcYC3IASr3sXZNC6e-6J-dRoPB2-Efo->

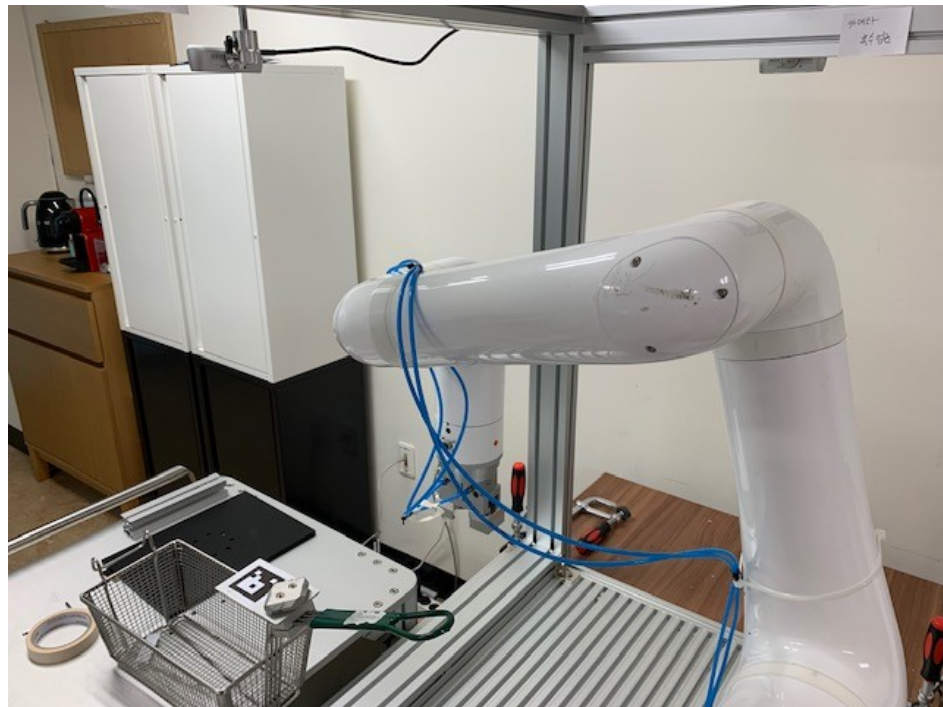
- Text Book

- <https://board.opa-x.com/domain/demo/board-list/3d9d5663-338d-48ba-b8b7-f2ac458630f6>

- Manual Page

- <http://things-board.hatiolab.com/ko/>

Vision Workspace Configuration



Robot



Camera

**Vision
Workspace**



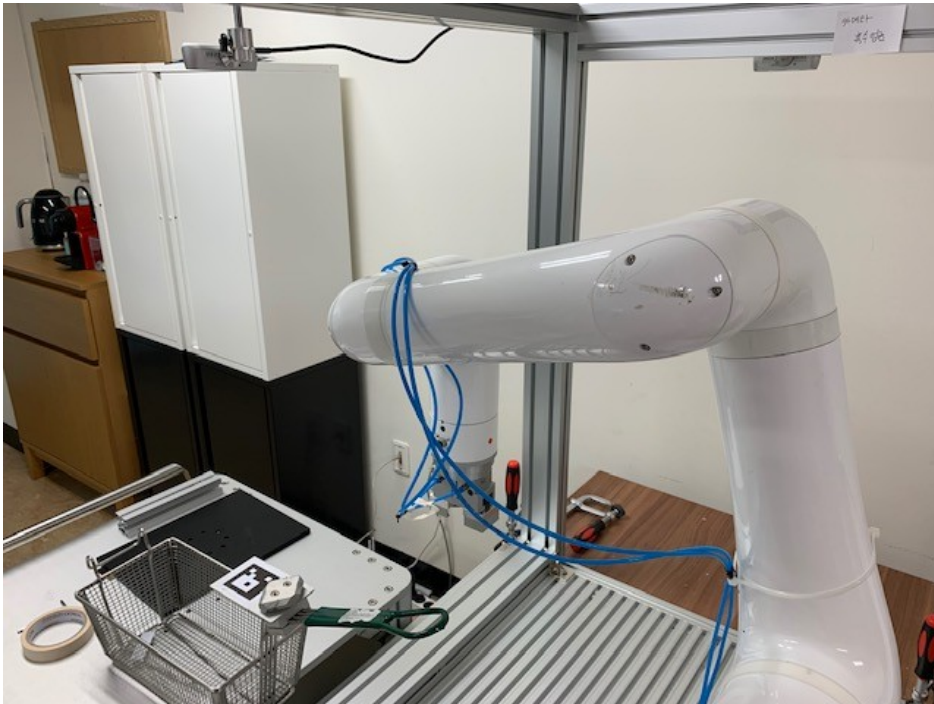
Marked Object

Robot

- Represent a robot arm entity in the system
- Endpoint is ethernet ip.
- Should link a robot connection before camera connector is created.

#	<input type="checkbox"/>	Name	Description	Active	Type	Endpoint	Parameters	Updater	Updated At
1	<input type="checkbox"/>	camera01		<input checked="" type="checkbox"/>	camera-connector	4	{"device":"","base	Admin	2020. 9. 16. 10시 25분 19초
2	<input type="checkbox"/>	camera02		<input checked="" type="checkbox"/>	camera-connector	10	{"device":"","base	Admin	2020. 9. 16. 10시 30분 44초
3	<input type="checkbox"/>	marker01		<input checked="" type="checkbox"/>	marked-object	3	{"type":"","poiOff	Admin	2020. 9. 10. 16시 12분 17초
4	<input type="checkbox"/>	robot01		<input checked="" type="checkbox"/>	indydcp-connector	192.168.0.207	{"robotName":"","NI	Admin	2020. 9. 17. 8시 5분 23초
5	<input checked="" type="checkbox"/>	workspace		<input checked="" type="checkbox"/>	tracking-workspace	0	Threshold	Admin	2020. 9. 17. 8시 5분 29초

Endpoint: Robot ethernet IP



Robot

Robot Parameters

Parameters

Robot Name

Marker Offset

X

0

Y

0

U

0

V

0

MODE CHANGE

OFF

RESET

HOME

Waypoint Offset

X

0

Y

0

U

0

V

0

MODE CHANGE

OFF

RESET

HOME

Tool Offset

X

0

Y

0

U

0

V

0

MODE CHANGE

OFF

RESET

HOME

CANCEL

CONFIRM

Choose robot name to connect a robot

Marker Offset: set the handeye calibration marker position based on tool center point(TCP) of robot.(optional)

Waypoint Offset: set the position which robot moves before picking an object. This position is based on object coordinates

Tool Offset: set the position of a tool based on TCP.

Camera

- Represent UVC-enabled cameras
- UVC-enabled camera has an camera number designated by OS and it is an endpoint.

Endpoint: camera number designated by OS
(ex: endpoint **4** : /dev/video**4** device in linux)

#	<input type="checkbox"/>	Name	Description	Active	Type	Endpoint	Parameters	Updater	Updated At
1	<input type="checkbox"/>	camera01		<input checked="" type="checkbox"/>	camera-connector	4	{"device":"","baseAdmin		2020. 9. 16. 10시 25분 19초
2	<input type="checkbox"/>	camera02		<input checked="" type="checkbox"/>	camera-connector	10	{"device":"","baseAdmin		2020. 9. 16. 10시 30분 44초
3	<input type="checkbox"/>	marker01		<input checked="" type="checkbox"/>	marked-object	3	{"type":"","poiOffsAdmin		2020. 9. 10. 16시 12분 17초
4	<input type="checkbox"/>	robot01		<input checked="" type="checkbox"/>	indydcp-connector	192.168.0.207	{"robotName":"","NIAdmin		2020. 9. 17. 8시 5분 23초
5	<input checked="" type="checkbox"/>	workspace		<input checked="" type="checkbox"/>	tracking-workspace	0	{"poseThreshold"Admin		2020. 9. 17. 8시 5분 29초



Camera

Camera Parameters

Vision Workspace

카메라 캘리브레이션

Camera Matrix

0

0

0

0

0

0

0

0

0

Distortion Coefficients

K1

0

P1

0

K3

0

K2

0

P2

0

RESET

TAKE SNAPSHOT

CALIBRATE

Turn On The Camera.

Choose robot arms here. Robot should be connected in advance.

파라미터

장치이름

베이스 로봇암

Setting

카메라 설정

distortion coefficients

0

0

0

0

0

camera matrix

0

0

0

0

0

카메라 캘리브레이션

Click this link to open camera calibration window.

ROI

0

0

0

0

0

ROI

0

0

0

0

0

핸드아이 매트릭스

0

0

0

0

0

핸드아이 캘리브레이션

Click this link to open handeye calibration window.

Label.Camera Object Offset

X

0

Y

0

Z

0

U

0

V

0

W

0

MODE CHANGE

OFF

RESET

HOME

취소

확인

Use this offset values to adjust fine position tuning for the object after handeye calibration.

핸드아이 캘리브레이션

Handeye Matrix

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

RESET

START TEACHING

FINISH TEACHING

TAKE SNAPSHOT

CALIBRATE

Turn On The Camera.

Camera Calibration

- Use 10x7 chessboard
- Can find the chessboard file in 'resources' directory of [git](#)

#	<input type="checkbox"/>		Name	Description	Active	Type	Endpoint	Parameters	Updater	Update
1	<input type="checkbox"/>		camera01		<input checked="" type="checkbox"/>	camera-connector	4	{'device': '', 'base Admin		
2	<input type="checkbox"/>		camera02		<input checked="" type="checkbox"/>	camera-connector	10	{'device': '', 'base Admin		2020. 9. 16. 10시 30분 44초
3	<input type="checkbox"/>		marker01		<input checked="" type="checkbox"/>	marked-object	3	{'type': '', 'poiOffs Admin		2020. 9. 10. 16시 12분 17초
4	<input type="checkbox"/>		robot01		<input checked="" type="checkbox"/>	indydcp-connector	192.168.0.207	{'robotName': 'NI Admin		2020. 9. 17. 8시 5분 23초
5	<input checked="" type="checkbox"/>		workspace		<input checked="" type="checkbox"/>	tracking-workspace	0	{'poseThreshold' Admin		2020. 9. 17. 8시 5분 29초

The image shows a software interface for camera calibration. The main window is titled "Camera Calibration" and contains the following sections:

- Camera Matrix:** A 3x3 grid of input fields for the camera matrix, all currently set to 0.
- Distortion Coefficients:** A section with input fields for K1, K2, K3, P1, and P2, all currently set to 0.
- Buttons:** "RESET", "TAKE SNAPSHOT", and "CALIBRATE".
- Camera View:** A large black rectangle on the right side with a camera icon and the text "Turn On The Camera."

In the background, a "Parameter" window is visible, showing various settings like "장치이름" (Device Name), "베이스 로봣암" (Base Load), and "카메라 설정" (Camera Setting). A yellow callout box with the text "2. Click 'Camera Calibration'" points to the "Camera Calibration" button in the background window.

Camera Calibration



4. You can start camera calibration after showing up the camera screen.

Short key:

'c' : capture the current screen
'g' : calculate the camera matrix
'q' : quit the camera calibration

Notice.

- Need 20~30 captures changing the pose of board to improve calibration accuracy
- Should display the entire chess board when capturing the frame

Camera Calibration

Camera Matrix

1370.7850717593549

0

970.9949773206218

0

1375.9074199071433

563.0838049692136

0

0

1

Distortion Coefficients

K1 0.10336747491192769

K2 -0.12067960818241279

P1 0.0009976616907020604

P2 0.0004614393945503234

K3 -0.2793101677986535

RESET

TAKE SNAPSHOT

CALIBRATE

Turn On The Camera.

5. Verify the camera matrix result and 'confirm' button and don't forget to click save button in 'connection list' menu.

CANCEL CONFIRM

- Could attach a needle on a board to select a...

아이 캘리브레이션

Handeye Matrix

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

RESET

START TEACHING

FINISH TEACHING

TAKE SNAPSHOT

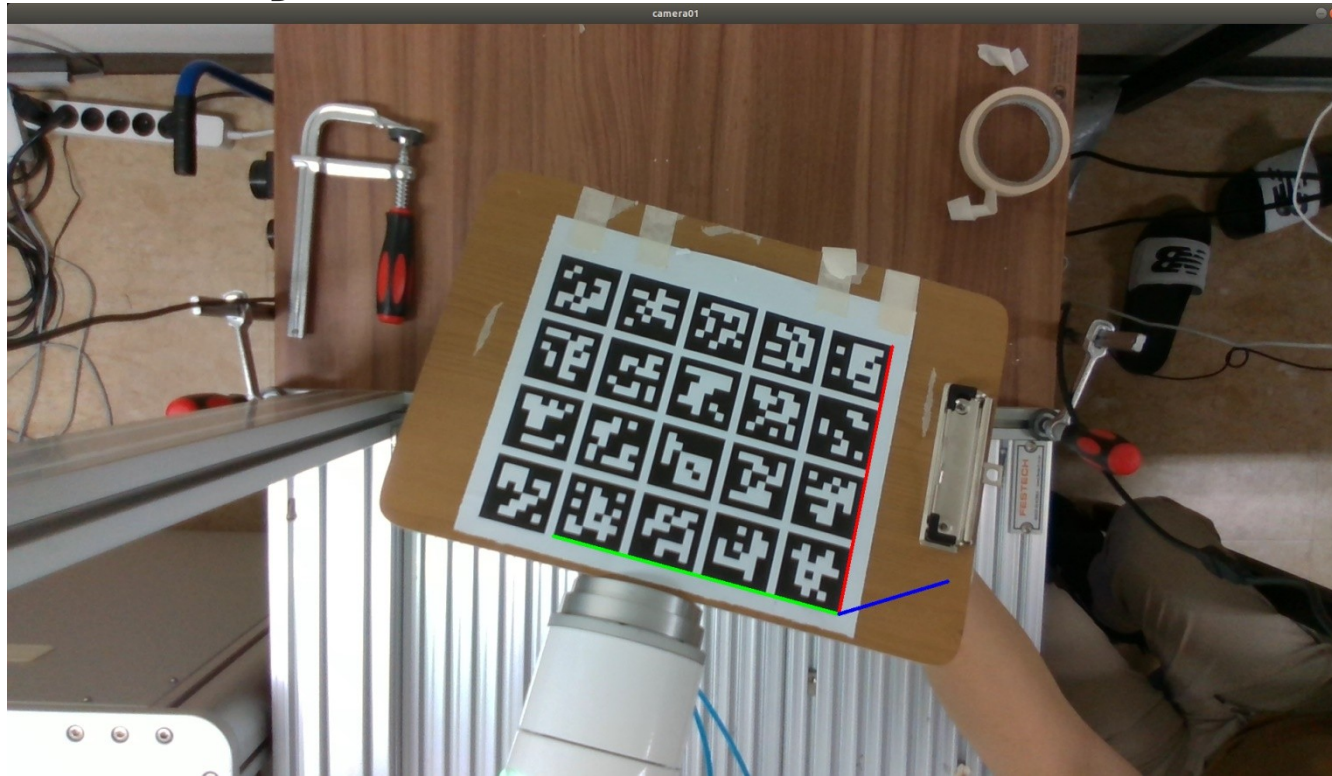
CALIBRATE

Turn On The Camera.

4. Click 'Calibrate' to start handeye calibration

change the robot mode teaching status.

Handeye Calibration



5. You can start handeye calibration after showing up the camera screen.

Short key:

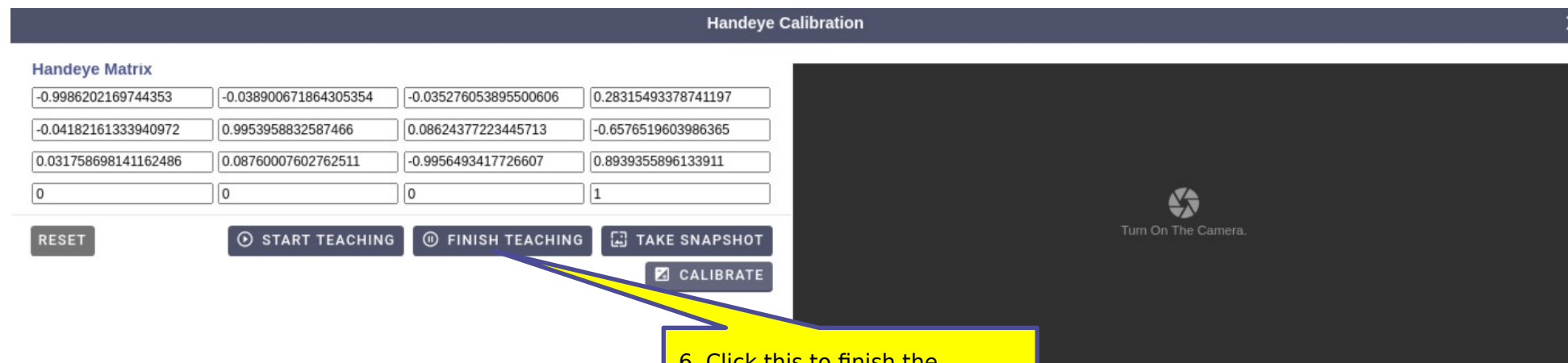
'c' : capture the current robot position and the pose of the object

'g' : calculate the handeye matrix

'q' : quit the handeye calibration

Notice.

- Need 30~40 captures while changing the robot position to improve calibration accuracy
- Don't move the robot to the position far from the screen center.



6. Click this to finish the teaching mode

7. Click confirm to finish handeye calibration

CANCEL CONFIRM

Fine Position Correction after Handeye Calibration

- Can adjust the fine position tuning for each camera if the picking position of object doesn't fit after handeye calibration.
- In camera parameter window,

Parameters

Base Robot-Arm

robot01

Setting

CAMERA SETTING

distortion coefficients

0.103367474911927

-0.12067960818241

0.000997661690702

0.000461439394550

-0.27931016779865

camera matrix

1370.7850717593549

0

970.9949773206218

0

1375.9074199071433

563.0838049692136

0

0

1

CAMERA CALIBRATION

ROI

ROI

-0.9986202169744353

-0.038900671864305354

-0.035276053895500606

0.28315493378741197

-0.04182161333940972

0.9953958832587466

0.08624377223445713

-0.6576519603986365

0.031758698141162486

0.08760007602762511

-0.9956493417726607

0.8939355896133911

0

0

0

1

HANDEYE CALIBRATION

Label.Camera Object Offset

X

0.005

Y

0.0

Z

0.0

U

0

V

0

W

0

MODE CHANGE

OFF

RESET

HOME

CANCEL

CONFIRM

Adjust the picking position here to change offset based on object marker coordinates

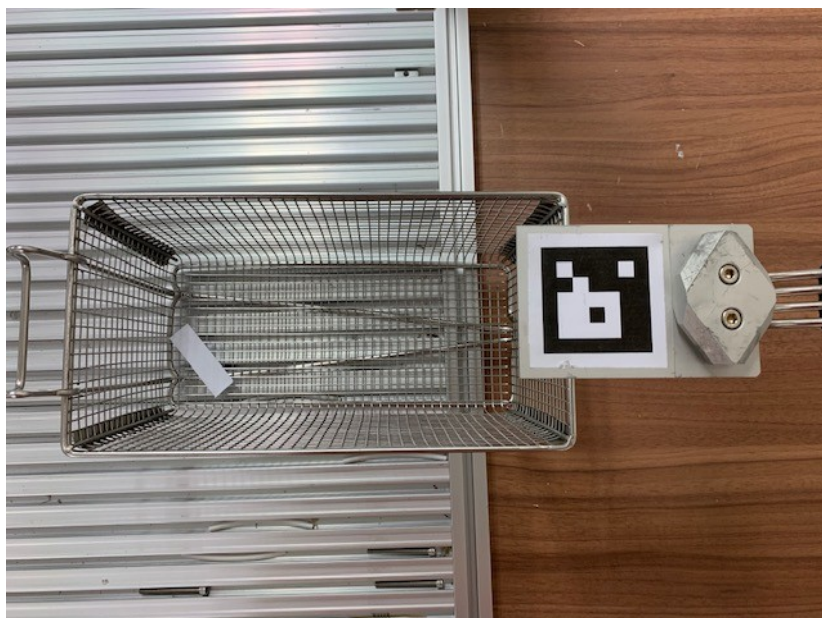
In this figure, robot arm move more to 5mm of x-axis direction based on the aruco marker.

Marked Object

- Represent a marked object like aruco
- Aruco-marked object has a number decided by aruco dictionary rule and it is an endpoint.

#	<input type="checkbox"/>	Name	Description	Active	Type	Endpoint	Updated At
1	<input type="checkbox"/>	camera01		<input checked="" type="checkbox"/>	camera-connector	4	{ "device": "", "base Admin
2	<input type="checkbox"/>	camera02		<input checked="" type="checkbox"/>	camera-connector	10	{ "device": "", "base Admin
3	<input type="checkbox"/>	marker01		<input checked="" type="checkbox"/>	marked-object	3	{ "type": "", "poiOffs Admin
4	<input type="checkbox"/>	robot01		<input checked="" type="checkbox"/>	indydcp-connector	192.168.0.207	{ "robotName": "NI Admin
5	<input checked="" type="checkbox"/>	workspace		<input checked="" type="checkbox"/>	tracking-workspace	0	{ "poseThreshold" Admin

Endpoint: aruco mark number



Marked Object

Marked Object Parameter

Parameters

Type

POI Offset

X

0.0

Y

0.05

Z

0

U

0

V

0

W

0

MODE CHANGE

OFF

RESET

HOME

POI means 'point of interest'.
POI offset represents picking position based on marker's center point. This offset is operated on aruco mark coordinates.

CANCEL CONFIRM

Workspace

- Represent a set of vision connections like camera, marked object and robots.
- Workspace is unique in this system
- Workspace succeeds to link this system and then run object tracking application automatically.

#	<input type="checkbox"/>		Name	Description	Active	Type	Endpoint	Parameters	Updater	Updated At
1	<input type="checkbox"/>		camera01		<input checked="" type="checkbox"/>	camera-connector	4	{ "device": "", "base Admin		2020. 9. 16. 10시 25분 19초
2	<input type="checkbox"/>		camera02		<input checked="" type="checkbox"/>	camera-connector	10	{ "device": "", "base Admin		2020. 9. 16. 10시 30분 44초
3	<input type="checkbox"/>		marker01		<input checked="" type="checkbox"/>	marked-object	3	{ "type": "", "poiOffs Admin		2020. 9. 10. 16시 12분 17초
4	<input type="checkbox"/>		robot01		<input checked="" type="checkbox"/>	indydcp-connector	192.168.0.207	{ "robotName": "NI Admin		2020. 9. 17. 8시 5분 23초
5	<input checked="" type="checkbox"/>		workspace		<input checked="" type="checkbox"/>	tracking-workspace	0	{ "poseThreshold" Admin		2020. 9. 17. 8시 5분 29초

Workspace Parameters

Parameters

Pose Threshold

X

0.1

Y

0.1

Z

0.1

U

5

V

5

W

5

MODE CHANGE

OFF

RESET

HOME

Pose Threshold is a criteria to check if the position of marked object is changed.
Pose estimation using aruco marker doesn't have fixed pose value for the stationary object with a little variation, so this threshold values might be needed.

CANCEL

CONFIRM

Queue-Based Tasks

- pend-up-scenario task
: put a scenario into the scenario queue with delay and priority

The screenshot shows a task configuration interface. A table lists tasks, with 'pend-up-scenario' selected. A 'Parameters' dialog is open, showing the following values:

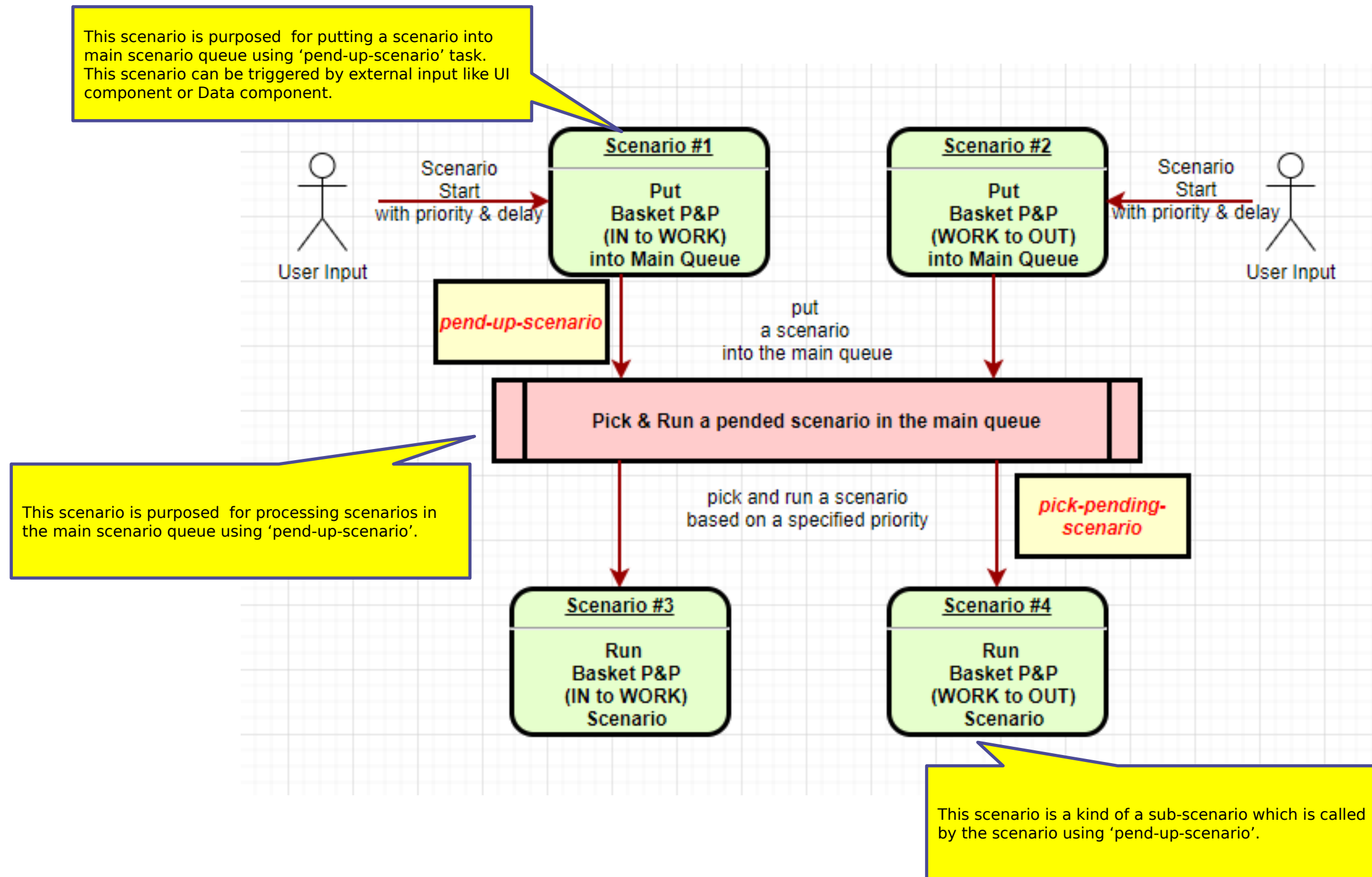
Parameter	Value
Scenario	2e3dd17e-b985-4008-aa0a-9635ec126984
Delay	0
Priority	3
Variables	VARIABLES
Tag	

- pick-pending-scenario
: fetch and run a scenario from the scenario queue based on delay and priority

The screenshot shows a 'Scenario Detail' dialog. A table lists tasks within the scenario, with 'pick' selected. The table shows the following configuration:

Task	Parameters
pick	pick-pending-scenar {}
delay	{ "duration": "1000" }
goto	{ "goto": "pick" }

Queue-Based Scenario Process



New Tasks

- tracking-ws-get-object-state

↑ ↓	move-to-incenter	<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydcp-move-to-pos {"accessor":"","pose":{"x":0.245280
↑ ↓	get-global-varialbes	<input type="checkbox"/>	<input checked="" type="checkbox"/>		variables
↑ ↓	get-object-position	<input type="checkbox"/>	<input checked="" type="checkbox"/>	workspace	tracking-ws-get-obje {"accessor":"get-global-varialbes.b

This workspace task is purposed for getting object positions. You can use 'variables' or 'data' to find out the position of the specific object.

- indydcp-move-to-pick

↑ ↓	get-object-position	<input checked="" type="checkbox"/>	<input type="checkbox"/>	marker01	trackable-object-get- {}
↑ ↓	move-to-marker	<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydcp-move-to-pic {"accessor":"get-object-position.po

This robot task is purposed for making robot arm moved to the picking position considering some offsets like 'POI', 'Tool', and so on. Also you can designate an waypoint before moving picking point.

Parameters

Accessor

get-object-position.pose

Pose

X

0

Y

0

Z

0

U

0

V

0

W

0

MODE CHANGE

OFF

RESET

HOME

☒ Label.ViaWaypoint

New Tasks

- indydc-p-move-to-pose
- indydc-p-move-by-pose

These tasks are purposed for making robot moved to the specific position and pose. 'move-to' task is for the absolute pose and position and 'move-by' task for the relative. 'program' task has multiple positions to move sequentially and can be played as well.

↑ ↓	move-by-midpoint	<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydc-p-move-by-po {"accessor":"","pose":{"x":0,"y":0
↑ ↓	move-to-rotate-1	<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydc-p-program {"program":[{"pose":{"x":0.1069808
↑ ↓	move-to-workcenter	<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydc-p-move-to-po {"accessor":"","pose":{"x":0.442241

You can test this specified position using this button.

You can use 'accessor' or 'XYZABC' coordinate for this task. 'accessor' has even higher priority than 'XYZABC' coordinate.

You can change robot teaching mode

The current robot position can be set by this button.

- indydc-p-program

This program task has the same parameter with 'move-to' task to specify a moving position .

Also, this task can have multiple moving position

Parameters

Offset

Y 0 Z 0

U 0 V 0 W 0

MODE CHANGE OFF RESET HOME

Program

rot-1

rot-2

rot-3

Key-in pose's name

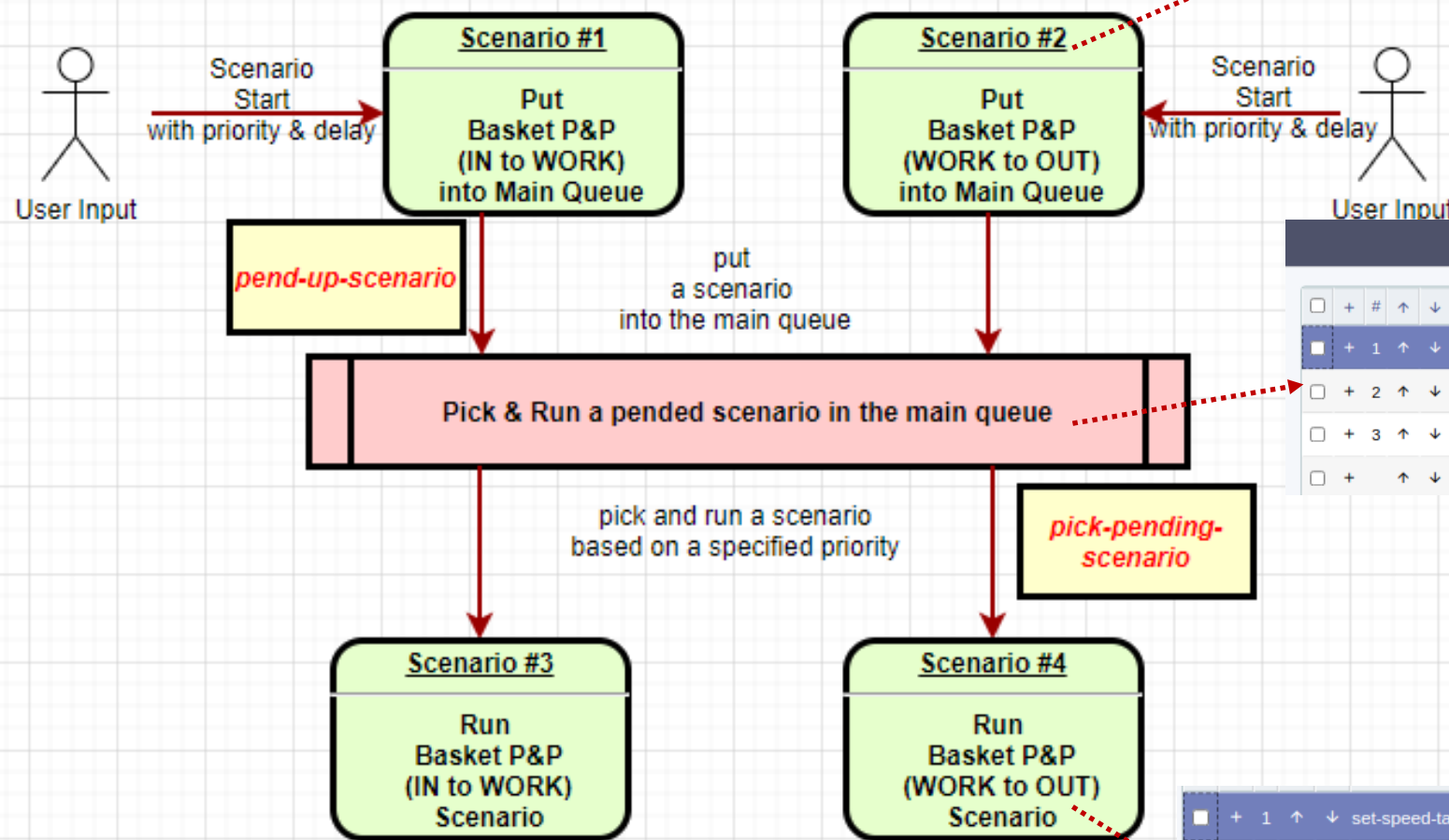
MODE CHANGE OFF RESET HOME PLAY

You can play multiple moving positions using this play button.

Vision-based picking scenario example

Input Scenario using 'put-pending-queue' task with external variables

	#	Name	Description	Skip	Log	Connection	Task	Parameters
<input type="checkbox"/>	1	VARIABLES		<input type="checkbox"/>	<input type="checkbox"/>		variables	
<input checked="" type="checkbox"/>	2	put-pending-queue		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		pend-up-scenario	{"scenario":"2e3dd17e-b"
<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>			



Scenario Detail								
	#	Name	Description	Skip	Log	Connection	Task	Parameters
<input checked="" type="checkbox"/>	1	pick		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		pick-pending-scenar	{}
<input type="checkbox"/>	2	delay		<input type="checkbox"/>	<input type="checkbox"/>		sleep	{"duration":"1000"}
<input type="checkbox"/>	3	goto		<input type="checkbox"/>	<input type="checkbox"/>		goto	{"goto":"pick"}
<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>			

<input checked="" type="checkbox"/>	1	set-speed-task		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	robot01	indydcp-set-speed	{"type":"TASK","level":"1"}
<input type="checkbox"/>	2	move-to-incenter		<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydcp-move-to-po	{"accessor":"","pose":{"x":0,"y":0,"z":0,"roll":0,"pitch":0,"yaw":0}}
<input type="checkbox"/>	3	get-global-varialbes		<input type="checkbox"/>	<input checked="" type="checkbox"/>		variables	
<input type="checkbox"/>	4	get-object-position		<input type="checkbox"/>	<input checked="" type="checkbox"/>	workspace	tracking-ws-get-obje	{"accessor":"get-global-"
<input type="checkbox"/>	5	get-object-position		<input checked="" type="checkbox"/>	<input type="checkbox"/>	marker01	trackable-object-get-	{}
<input type="checkbox"/>	6	move-to-marker		<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydcp-move-to-pic	{"accessor":"get-object-"
<input type="checkbox"/>	7	grip-in-sleep		<input type="checkbox"/>	<input type="checkbox"/>		sleep	{"duration":"5000"}
<input type="checkbox"/>	8	move-by-midpoint		<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydcp-move-by-po	{"accessor":"","pose":{"x":0,"y":0,"z":0,"roll":0,"pitch":0,"yaw":0}}
<input type="checkbox"/>	9	move-to-rotate-1		<input type="checkbox"/>	<input type="checkbox"/>	robot01	indydcp-program	{"program":[{"pose":{"x":0,"y":0,"z":0,"roll":0,"pitch":0,"yaw":0}}