OMRON

Omron TM Collaborative Robot: TMVision Software Manual

TM ROBOT

Original Instruction

I690-E-03

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Revision History Table

Revision	Date	Revised Content
A	June, 2023	Original release
B	March, 2024	Minor revision
C	August, 2024	Minor revision

1. General

1.1 Overview

TMvision is a combined hardware and software built-in feature of TM Robot. Regarding the hardware: There is a visual camera module at the end of the TM Robot for users to experience complete visual software functionalities.

With approvals from a variety of robot vision manufacturers, TMvision comes with functions such as feature identification, object location, enhance mode, barcode identification as well as color classifier integrated into TMflow for users to design the robot task step by step.

TM Robot's built-in Vision Designer supports Eye-in-Hand (EIH), Eye-to-Hand (ETH), and Upward-Looking cameras with balanced high-level integration and multiple supports. The hardware and software integrated internal Vision Designer does away with the complex vision components of conventional systems, and saves the time in getting familiar with robots that users may know little about. For users familiar with robot and machine vision, TMvision comes with a wide range of assistance and integration tools for users to generate diversified visual robot integration platforms

This manual begins with the built-in EIH camera to outline the TM-exclusive Task Designer system with the built-in camera. It then describes optical character recognition (OCR) functions and ends with the external camera's software and hardware integration.

This manual applies to TMflow Version 2.18. There will be differences between the functions and interfaces of different software versions. Confirm the software version before using and reading this manual. To confirm the software version, click at the top right of the screen for the information. For the applicability of this software to the hardware versions of each TM Robot, please refer to Chapter 1.1 Overview in the *Omron TM Collaborative Robot: Software Manual TMFlow, Version 2 (Cat. No. I689)*.

Note

NOTE:
In this software, the naming rules for custom names and paths are restricted to use: letters (both uppercase and lowercase letters), digits, and underscore.

1.2 Warning and Caution Symbols

The Table below shows the definitions of the warning and caution levels used in our manuals. Pay close attention to them when reading each paragraph, and observe them to avoid personal injuries or equipment damage.

	DANGER: Identifies an imminently hazardous situation which, if not avoided, is likely to result in serious injury, and might result in death or severe property damage.
	WARNING: Identifies a potentially hazardous situation which, if not avoided, will result in minor or moderate injury, and might result in serious injury, death, or significant property damage.
	CAUTION: Identifies a potentially hazardous situation which, if not avoided, might result in minor injury, moderate injury, or property damage.

Table 1: Danger, Warning, and Caution Symbols

1.3 Safety Precautions

DANGER:
This product can cause serious injury or death, or damage to itself and other equipment, if the following safety precautions are not observed:

- All personnel who install, operate, teach, program, or maintain the system must read the *Omron TM Collaborative Robot S Series: TM5S and TM7S Hardware Installation Manual (Cat. No. I686), Omron TM Collaborative Robot S Series: TM12S and TM14S Hardware Installation Manual (Cat. No. I687), Omron TM Collaborative Robot S Series: TM25S Hardware Installation Manual (Cat. No. M104), Omron TM Collaborative Robot: Software Manual TMFlow, Version 2 (Cat. No. I689)*, and *Omron TM Collaborative Robot S Series: Safety Manual (Cat. No. I688)* according to the software and hardware version of this product, and complete a training course for their responsibilities in regard to the robot.

Read Manual Label; Impact Warning

- All personnel who design the robot system must read the *Omron TM Collaborative Robot S Series: TM5S and TM7S Hardware Installation Manual (Cat. No. I686), Omron TM Collaborative Robot S Series: TM12S and TM14S Hardware Installation Manual (Cat. No. I687), Omron TM Collaborative Robot S Series: TM25S Hardware Installation Manual (Cat. No. M104), Omron TM Collaborative Robot: Software Manual TMFlow, Version 2 (Cat. No. I689)*, and *Omron TM Collaborative Robot S Series: Safety Manual (Cat. No. I688)* according to the software and hardware version of this product, and must comply with all local and national safety regulations for the location in which the robot is installed.
- The TM Robot must be used for its intended use.

- Results of the risk assessment may require the use of additional risk reduction measures.
- Power to the robot and its power supply must be locked out and tagged out or have means to control hazardous energy or implement energy isolation before any maintenance is performed.
- Dispose of the product in accordance with the relevant rules and regulations of the country or area where the product is used.

1.4 Validation and Liability

The information contained herein neither includes how to design, install, and operate a complete robotic arm system, nor involves the peripherals which may affect the safety of the complete system. The integrators of the robot should understand the safety laws and regulations in their countries and prevent hazards from occurring in the complete system.

This includes but is not limited to:

- Risk assessment of the whole system
- Adding other machines and additional risk reduction measures based on the results of the risk assessment
- Using appropriate software safety features
- Ensuring the user will not modify any safety measures
- Ensuring all systems are correctly designed and installed
- Clearly labeling user instructions
- Clearly marked symbols for installation of the robot arm and the integrator contact details
- Making accessible relevant documents, including the risk assessment and this Manual

> **CAUTION:**
> This product is a partly complete machine. The design and installation of the complete system must comply with the safety standards and regulations in the country of use. The user and integrators of the robot should understand the safety laws and regulations in their countries and prevent major hazards from occurring in the complete system.

1.5 Limitation of Liability

No safety-related information shall be considered a guarantee by the Corporation that a TM Robot will not cause personnel injury or property damage.

1.6 Statement of Responsibilities for Cybersecurity Threats

To maintain the security and reliability of the system, a robust cybersecurity defense program should be implemented, which may include some or all of the following:

Anti-virus protection

- Install the latest commercial-quality anti-virus software on the computer connected to the control system and keep the software and virus definitions up-to-date.
- Scan USB drives or other external storage devices before connecting them to control systems and equipment.

Security measures to prevent unauthorized network access

- Install physical controls so that only authorized personnel can access control systems and equipment.
- Reduce connections to control systems and equipment via networks to prevent access from untrusted devices.
- Install firewalls to block unused communications ports and limit communication between systems. Limit access between control systems and systems from the IT network.
- Control remote access and adopt multifactor authentication to devices with remote access to control systems and equipment.
- Set strong password policies and monitor for compliance frequently.

Data input and output protection

- Backup data and keep the data up-to-date periodically to prepare for data loss.
- Validate backups and retention policies to cope with unintentional modification of input/output data to control systems and equipment.
- Validate the scope of data protection regularly to accommodate changes.
- Check validity of backups by scheduling test restores to ensure successful recovery from incidents.
- Safety design, such as emergency shutdown and fail-soft operations in case of data tampering and incidents.

Additional recommendations

- When using an external network environment to connect to an unauthorized terminal such as a SCADA, HMI or to an unauthorized server may result in network security issues such as spoofing and tampering.
- You must take sufficient measures such as restricting access to the terminal, using a terminal equipped with a secure function, and locking the installation area by yourself.
- When constructing network infrastructure, communication failure may occur due to cable disconnection or the influence of unauthorized network equipment.
- Take adequate measures, such as restricting physical access to network devices, by means such as locking the installation area.
- When using devices equipped with an SD Memory Card, there is a security risk that a third party may acquire, alter, or replace the files and data in the removable media by removing or unmounting the media.

1.7 Functional Note Symbols

The following table defines the functional note symbols used in this manual. Read the paragraphs carefully.

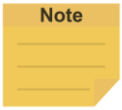
	**IMPORTANT:** This symbol indicates the relevant functional details to assist programming and use.
	**NOTE:** This symbol indicates the relevant functional use tips to assist programming efficiency.

Table 2: Function Note Symbols

2. Eye-in-Hand

2.1 Overview

The TM Robot's built-in Vision Designer system integrates hands, eyes and brains of conventional robots into one. This not only enables users to execute high precision jobs but also provides flexibility for fast line changes. Regarding hardware operation, users can move the robot to right above the object and press the Vision button on the camera to generate a Vision node in TMflow for subsequent visual job programming. Refer to the relevant *Omron TM Collaborative Robot S Series: TM5S and TM7S Hardware Installation Manual (Cat. No. I686), Omron TM Collaborative Robot S Series: TM12S and TM14S Hardware Installation Manual (Cat. No. I687), Omron TM Collaborative Robot S Series: TM25S Hardware Installation Manual (Cat. No. M104)* for the position of the buttons.

TMvision is designed for coordinate adjustment and vision job administration, and users can set parameters of visual features on lighting and imaging in the Vision node to enhance the speed and quality of identification. Refer to the following chapters for details and instructions.

Note

NOTE:
Users should check if the connection of User Connected External Safeguard Input for Human-Machine Safety Setting on the control box is closed before proceeding a conclusive calibration. For details of User Connected External Safeguard Input for Human-Machine Safety Setting, refer to *Omron TM Collaborative Robot S Series: Safety Manual (Cat. No. I688)*, the relevant *Omron TM Collaborative Robot S Series: TM5S and TM7S Hardware Installation Manual (Cat. No. I686), Omron TM Collaborative Robot S Series: TM12S and TM14S Hardware Installation Manual (Cat. No. I687), Omron TM Collaborative Robot S Series: TM25S Hardware Installation Manual (Cat. No. M104)*, and *Omron TM Collaborative Robot: Software Manual TMFlow, Version 2 (Cat. No. I689)*.

2.2 Vision Base System Positioning Mode

The Vision Base System Positioning Mode is a feature exclusive to the Positioning Node. TM Robot comes with a 2D camera as the built-in vision system that supports the positioning model on the object-oriented base or the robot alignment-oriented base. For the object-oriented base positioning model, users must create a workspace and make sure the workspace is parallel to the object. Failure to do so may result in distorted imaging and visual identification job failures. TMvision offers five positioning methods: OMRON Landmark, three-OMRON Landmark, object positioning, servoing, and object-based calibration as described below.

2.2.1 OMRON Landmark Positioning

OMRON Landmark provides a fast, simple and flexible base system positioning method as a reference to the environment. Capturing OMRON Landmark with TM Robot will generate the position information of six degrees of freedom (including X, Y, Z, RX, RY, RZ) once to build a base system accordingly for users to record following points and motions. When the robot is repurposed or relocated, when the relative position of the robot and landmark changed, it's simple - use the robot to take a photo of OMRON Landmark again, to regain 6 DoF of the new location and renew the landmark base system. The recorded points and motions on the Landmark base system will be converted to the base system automatically to make the robot move to the same positions as before.

OMRON Landmark is a 0.2 cm thick and 5x5 cm square plastic plate as shown in the figure below. By capturing and recognizing OMRON Landmark's black and white borders and central graphic features through TM Robot's EIH camera, the robot can create the base system in the center of the OMRON Landmark's black and white border. Note that the accuracy of landmark positioning is not sufficient for identification and alignment purpose. In principle, OMRON Landmark is not designed for users to have the robot directly go to individual points or execute motions after creating a base system. Instead, it is an alignment tool to lead the robot toward a valid visual point. Users should use the TM Robot visual positioning function to identify and locate the object in the last step to get the best results.

OMRON Landmark generates a base system with six degrees of freedom, and the data in the RX, RY, and Z directions are not easy to obtain accurately with EIH 2D vision (i.e. whether the camera plane is parallel to the object and how long is the distance between the camera plane and the object). OMRON Landmark can enhance the positioning ability of the 2D vision along these axes. Despite the fact that OMRON Landmark is able to get the data of the X, Y, and RZ direction, chances are users may fail to place or attach OMRON Landmark precisely in the operating environment, it is not recommended to use the data directly for positioning. Due to the fact that these three degrees of freedom compensate the positioning of the base data in EIH 2D vision, users should use both methods. As a regular approach, users should use OMRON Landmark to have the robot guide its relative relationship between the peripherals or the RX, RY, and the Z axes. That is to say, using the positioning of OMRON Landmark on the three axes to ensure the visual points recorded in the OMRON Landmark base system after updating with the landmark base system of the visual point camera posture, are able to return back to the state of parallel with workpiece features (RX, RY) and to the correct distance to workpiece features (Z). Users can then use this positioning as the basis for a subsequent 2D vision job, and use each of the TMvision 2D functions to align the remaining axial directions of X, Y and RZ. Even if the relative position between base of robot and the OMRON Landmark changes, users can reuse the points and the motions recorded in the landmark base system from the former project by having the robot shoot the OMRON Landmark again.

When planning a project, users may place OMRON Landmark in the target task environment to create a TM Robot vision job and perform subsequent motions with the base system. Shooting the OMRON Landmark again in later operations will have the robot reset to the original base system automatically, i.e. to change alignment of robot according to site conditions without being confined to a fixed alignment. Users can use a custom OMRON Landmark with 1 to 20 cm in length and width—depending on their vision jobs—and use it during fixed positioning.

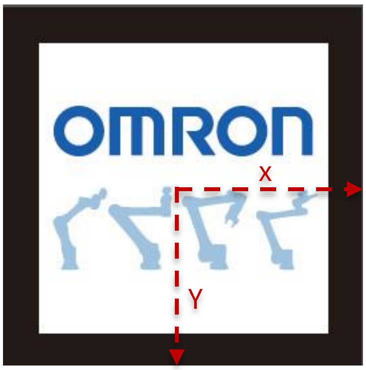
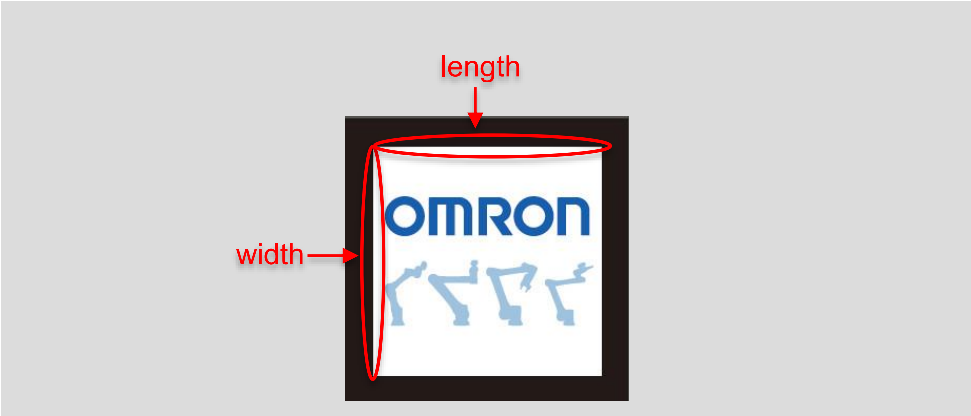


Figure 1: OMRON Landmark

Note

NOTE:

- The farther away the OMRON Landmark is from the camera the less accurate the alignment will be. The tradeoff is that a bigger field of view tends to capture changes of relative alignment between the robot and the OMRON Landmark. A shorter distance between the camera and Landmark has the advantage of better alignment accuracy but at the cost of a smaller field of view and Landmark's easily falling outside the field view. Users are advised to edit two vision jobs: one nearer and the other farther, when using OMRON Landmark. The farther one is aimed to quickly detect the OMRON Landmark in a workspace to create the first base system. Then, pull the robot close while orienting the RX, RY, and RZ angles of the second visual points (set these axes in the original base system orthogonal) to zero and keep them as close as possible, e.g. camera and OMRON Landmark 10 cm apart from each other. Shoot the same OMRON Landmark to get a more accurate Landmark base system.
- The custom OMRON Landmark’s length and width are the size measurements inside the black square.



2.2.2 Three-OMRON Landmark Positioning

Three-OMRON Landmark positioning is a significant improvement on OMRON Landmark positioning that enables higher accuracy of vision positioning, is three to six times more accurate at all photographing distances, and like OMRON Landmark positioning, provides a fast, simple and flexible positioning method. This positioning method involves a TM Robot photographing three OMRON Landmarks at the same time to obtain six degrees of freedom (X, Y, Z, RX, RY, and RZ) and create a vision base accordingly.

The origin and axial directions of the vision base created on the basis of three OMRON Landmarks are depicted in the image below:

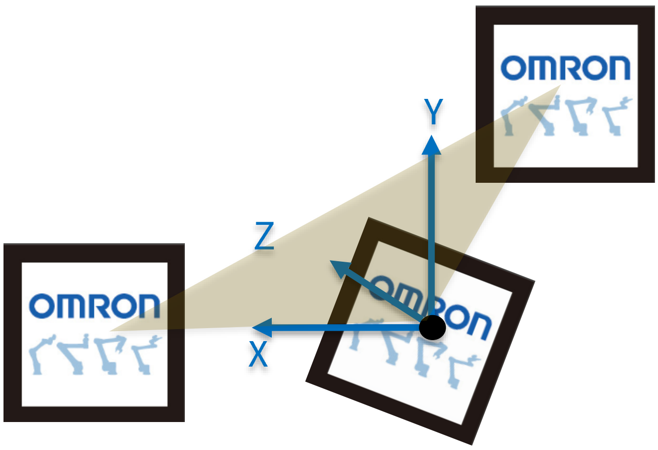


Figure 2: Vision base created on the basis of three OMRON Landmarks

Origin of the vision base: The largest included angle of the triangle formed when the centers of three OMRON Landmarks connected with each other.

Axial directions of the vision base:

- X: The first side encountered when the bisector of the largest included angle of the triangle formed by the centers of three OMRON Landmarks rotates counter-clockwise.
- Y: When the X-axis rotates 90 degrees clockwise on the plane formed by the centers of three

Landmark.

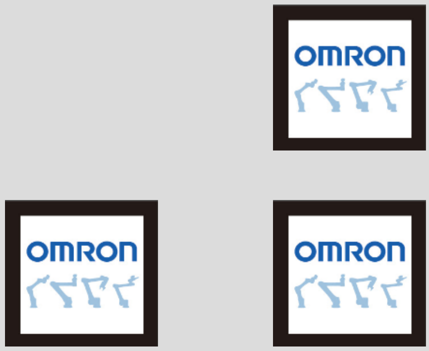
- Z: The cross product of the X and Y-axes. When an OMRON Landmark is laid flat, the Z-axis goes downward.

The origin and axial directions of the vision base are related not to the rotational angles of the OMRON Landmarks but to the centers of the Landmarks.

Note

NOTE:

Place the three OMRON Landmarks in the shape of a right triangle, with the largest included angle formed by the centers of the Landmarks approaching 90 degrees. This way, the vision base will become more stable and positioning accuracy will improve.



Three-OMRON Landmark positioning and OMRON Landmark positioning differ in what constitutes a vision base. For details about how to create a vision base using an OMRON Landmark, see 2.2.1 OMRON Landmark Positioning. Three-OMRON Landmark positioning can be performed using square-shaped OMRON Landmarks of the same custom size, from 1 to 20 cm.

2.2.3 Object Positioning

The object positioning function is designed with a pre-set object placement area and pre-set height for vision jobs. Users can create a workspace with the TM calibration plate. When using the TM calibration plate for object positioning, the relative height of the camera and the work plane is also defined. When using object positioning to establish a workspace, users must ensure that the absolute height of camera and object is equal to the workspace created by the TM calibration plate.

Figure 3: Object Positioning

2.2.4 Servoing

The servoing function is for users to define the object features. In each servoing process, TMvision automatically sets the robot position based on the defined object to return the relative position of the camera and object.

2.2.5 Object-based Calibration

The principle of object-based calibration is basically teaching as servoing and ending as object positioning. First, run the tilt correction with the calibration plate to define the servoing workspace with the actual workpiece and convert to the fixed point positioning with calculations. Since the servo calibration is used only when defining the workspace for the first time, the robot will place the workpiece at the four corners of the camera’s field of view to create the workspace with four movements and make the fixed-point positioning calculation with the workspace accordingly. This takes advantage of the fixed positioning's speed for positioning and the servoing without the calibration plate. For the object calibration, the features of the object should not be too big to fit in the field of view during the servo calibration.

2.3 Camera List

The list of cameras on the left side of TMvision shows the cameras in use and their status. Users can refresh the list and find any external camera on it.

2.4 Controller

To help users control the robot movements, TMvision provides the controller interface for users to move the robot to the appropriate positions and edit vision jobs.

2.5 Camera Kit

The camera kit is used to adjust camera imaging, including the following settings:

Name	Function
Camera Parameter Setting	Includes shutter and focus for the built-in camera and contrast and white balance for extracted images. All modules feature auto once function. Click Save to validate change made after adjustment jobs ended.
Focus / Aperture	To assist adjusting focus and aperture of an external camera. It provides visual tools for easy regulation. Users may read the scores of the current focus and aperture on the left, which vary with change in focus and aperture with the external camera. The calibration ends when the scores hit the Max line and stop rising even after more adjustment.
Luminance Distribution	Includes illuminance visualization tool to enable users adjusting lighting tools for optimized illumination distribution. The left side controls sensitivity of the visualization tool. The two track bars in the settings indicate the upper and lower limits of the visualization display. The brightness over the upper and lower limits are defaulted to their limits for display. If the illuminance in the field of view is uniform, colors shown by visualization tools may be close to each other in case of high sensitivity (upper and lower slides being farthest away from each other).
Tilt-Correction	Secure OMRON Landmark or calibration plate to the target plane as a calibration tool to enable the robot's automatic adjustment to the tilt angle and vertical alignment of the camera to target plane. Adjust camera parameter settings to ensure OMRON Landmark or the calibration plate is detectable before running tilt-correction. Keep adequate clearance around the robot, as in an automatic tilt-correction process the robot will move around its current position.

Table 3: Camera Kit Functions

Note

NOTE:

1. The default resolution of the camera is 5M pixels, and so is the production calibration. 5M pixels positioning is supported in Fixed Point and Landmark.
2. Previous vision jobs built with 1.2M pixels will retain previous settings.
3. When the ambient light illumination is less than 300 (cd/m^2), please enable built-in lighting.

2.6 Workspace Calibration

Workspace calibration includes automatic and manual calibration to help users create workspaces for fixed-point vision jobs. Workspace calibration will generate the information of the workspace as well as the VPoint. Refer to *Expression Editor and Listen Node* for details of VPoint.

Access workspace calibration through **Configuration** > **Vision Settings** > **Calibration**. Then select the eye-in-hand camera to do calibration.

2.6.1 Automatic

After a simple setup, users can run automatic workspace calibration or set the calibration parameters as needed.

- Hardware setup
  1. Place the calibration plate: The plate must be placed in the workspace.
  2. Adjust the image-capture position: Move the robot to its initial position. The camera should be placed 10 to 30 cm above the calibration plate to make sure the plate is detected.
- Parameter settings
  1. **Skip Tilt Correction**: Automatic workspace calibration includes skip-tile correction. If you want to maintain the robot's initial position and posture, you can tick the "Skip Tilt Correction" box to ignore tilt correction.

Note

NOTE:
Tilt correction changes the robot's initial position and posture to make sure the camera is level with the calibration plate. Users are best advised to perform tilt correction be performed; without it, calibration accuracy may decline.

  2. **Calibration Plate Thickness Compensation**: The calibration plate has some thickness of its own, and its thickness can be compensated for by setting this parameter (1.8 mm by default) to have the calibration distance aligned with the actual operation surface.

Note

NOTE:
Since the calibration distance does not change, the robot will lower its initial image-capture position to align with the distance if Calibration Plate Thickness Compensation is set.

After the hardware setup and parameter settings are completed, workspace calibration will begin automatically. Once the calibration procedure is finished, users can check the calibration accuracy and save this result as a workspace file. The workspace file can be used in fixed-point vision jobs.

IMPORTANT

IMPORTANT:
Keep adequate clearance for the robot, as it moves around its initial position during automatic calibration.

2.6.2 Manual

Manual calibration involves four steps: **Set Workspace**, **Select Tool**, **Workspace Calibration**, and **Save Result**.

NOTE:
Before starting calibration: Mount the required calibration tool on the robot tool flange. Techman Robot recommends using the calibration pin set provided by Techman Robot as the calibration tool. Use TMflow (TCP Setting) to set the Z height of the calibration tool.

IMPORTANT:
Once set up, do not move the calibration plate until the completion of the calibration process.

Step 1 Set Workspace:

After a simple hardware setup is completed, set the calibration parameters as needed.

1. Place the calibration plate: The plate must be placed in the workspace.
2. Adjust the image-capture position: Move the robot to its initial position. The camera should be placed 10 to 30 cm above the calibration plate to make sure the plate is detected.

- Parameter settings
    1. **Skip Tilt Correction**: Workspace calibration includes skip-tile correction. If you want to maintain the robot's initial position and posture, you can tick the "Skip Tilt Correction" box to ignore tilt correction.

    NOTE:
    Tilt correction changes the robot's initial position and posture to make sure the camera is level with the calibration plate. Users are best advised to perform tilt correction be performed; without it, calibration accuracy may decline.

    2. **Calibration Plate Thickness Compensation**: The calibration plate has some thickness of its own, and its thickness can be compensated for by setting this parameter (1.8 mm by default) to have the calibration distance aligned with the actual operation surface.

NOTE:
Since the calibration distance does not change, the robot will lower its initial image-capture position to align with the distance if Calibration Plate Thickness Compensation is set.

Step 2 Select Tool

Select a TCP for calibration

Step 3 Workspace Calibration

Follow the instructions to point the calibration tool to the calibration plate grid as shown on the screen, and click **Next**. Repeat this step five times. Use the controller when performing this step.

Step 4 Save Result

Confirm the calibration accuracy and save this result as a workspace file. The workspace file can be used in fixed-point vision jobs.

2.7 Live Video

Live Video provides a live camera image with functions at the bottom (from left to right): zoom out, display ratio, zoom in, play/pause, play once, and show the reference line.

Figure 4: Live Video

Functions	Suitable for hand-eye relationship
Zoom out Zoom in	The Eye-in-hand / eye-to-hand function is designed to change display ratio of the camera. This zooms in and out image displayed without changing the scope of extraction by the camera.
Play/Pause Play Once	Set up extract mode (default = continuous extract) for users convenience to capture current image shown on camera; pause extract: to freeze image and stop capturing; extract once: to get current image when pressing the extract button.
Show the reference line	Turn on a grid at the center of the live video to help composition.

Table 4: Live Video Functions

NOTE:
Users can move the mouse cursor anywhere on the screen to view the coordinates and the RGB values of the pixel in the live video.

2.8 Task Designer

TMvision provides users with a means of editing visual work, see Chapter 3 Task Designer for details.

2.9 External Hard Drive

External Hard Drive provides users with the ability to manage photo storage space and requires the TM SSD (sold separately) to save source images or result images for analysis. Images can be saved in **png**, **jpg**, or **bmp**. JPG Quality can be set to **Default**, **Storage Effficiency**, or **Extremely Low**. The **Source Image** is saved as **png** by default, the **Result Image** as **jpg**. The pie chart in the bottom left displays used space, available space, and reserved space. Users may check from **Do not save data** or **Delete from the oldest data** in **Stop status handling.** Click the **File Path** field to assign the path to store files, and drag the slider to configure the size reserved for the free space. Also, users may check **Show warning message only** or **Stop robot** for the **Action when saving images to SSD fails**. **Show warning message only** will display the warning message in the log of TMflow while **Stop robot** makes the robot stops for the saving error.

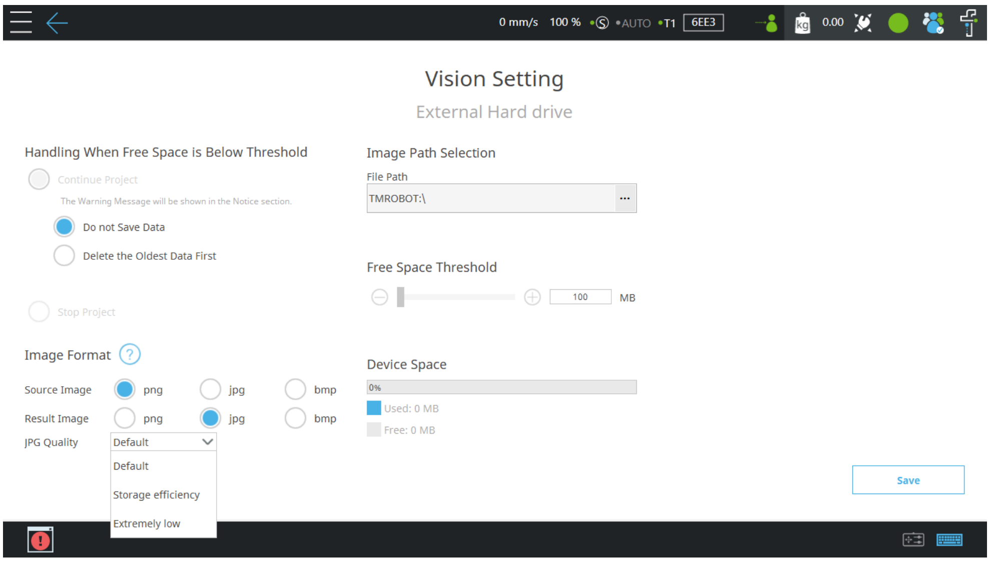


Figure 5: Hard Drive Setting

NOTE:
It is favored to set the SSD reserved free space to 30% of the SSD total storage space.

3. Task Designer

3.1 Overview

A TMvision task can be designed in different ways, depending on whether it is set up through a Positioning or Inspection node. Tasks that are set up through a Positioning node are categorized as the following applications: Object Positioning, Landmark Positioning, Servoing, Landmark PositioningObject-based Calibration, and Smart-Pick. Those that can be set up through an Inspection node are categorized as the following applications AOI and Vision IO. Users can select any of the applications and execute tasks with the corresponding algorithms.

In addition to Vision IO and AOI identification, other applications can use the Find function to position the base system to establish the relationship between the robot motion and the visual components. As shown in the figure below, record point P1 on vision base system 2 and create relative relationship with the object to access object visually.

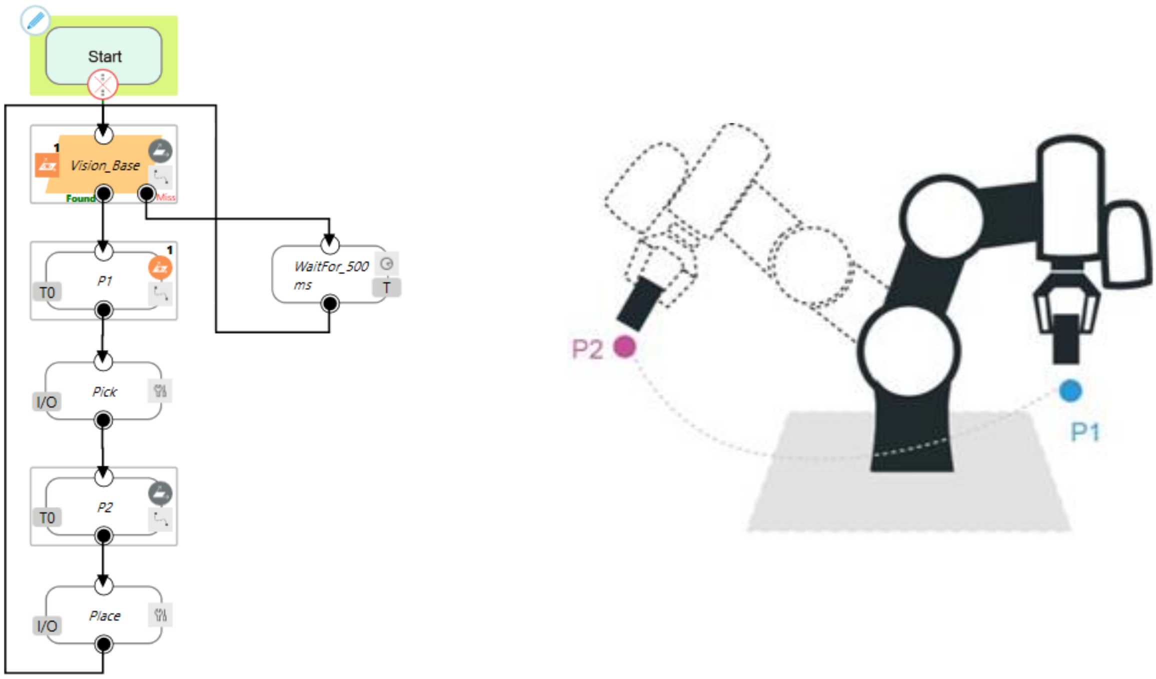


Figure 6: The Flow of Pick and Place

IMPORTANT:

- When using a vision base system, select the current base system shown at the top right of TMflow as the vision base system.
- In TMflow 2.16 (or its earlier versions), vision nodes, you can only edit existing vision jobs in vision nodes and cannot add any vision jobs or save them separately.
- In TMflow 2.16 (or its earlier versions), you can only edit existing modules in vision jobs and cannot add or delete any modules.

NOTE:
In case of invalid selection, re-record the base system with the "Re-record on another base “ in the Point Manager.

3.2 Select Application

Select the TMvision Task Designer in the work list and choose appropriate application according to intended use. Basic categories are as follows:

<table>
<tr><th>Node</th><th>Applications</th><th>Applicable hand-eye relationship</th><th>Workspace</th><th>Base system output</th></tr>
<tr><td rowspan="5">Positioning</td><td>Object Positioning</td><td>Eye-in-Hand / Eye-to-Hand</td><td>✓</td><td>Create base system based on object position</td></tr>
<tr><td>Servoing</td><td rowspan="4">Eye-in-Hand</td><td>×</td><td>Create base system based on the robot position</td></tr>
<tr><td>Landmark Positioning</td><td>×</td><td>Create base system based on Landmark position</td></tr>
<tr><td>Object-based Calibration</td><td>×</td><td>Create base system based on object position</td></tr>
<tr><td><u>Smart-Pick</u></td><td>✓</td><td>Create base system based on object position</td></tr>
<tr><td rowspan="2">Inspection</td><td>AOI</td><td>Eye-in-Hand / Eye-to-Hand</td><td>×</td><td>×</td></tr>
<tr><td>Vision IO</td><td>Eye-in-Hand / Eye-to-Hand</td><td>×</td><td>×</td></tr>
</table>

Table 5: Select Applications

Users can save vision images by setting I/O parameter and criteria based on the results of object detections, recognitions, and measurements. Images available to save include the original image (source image) and the last image taken (result image).

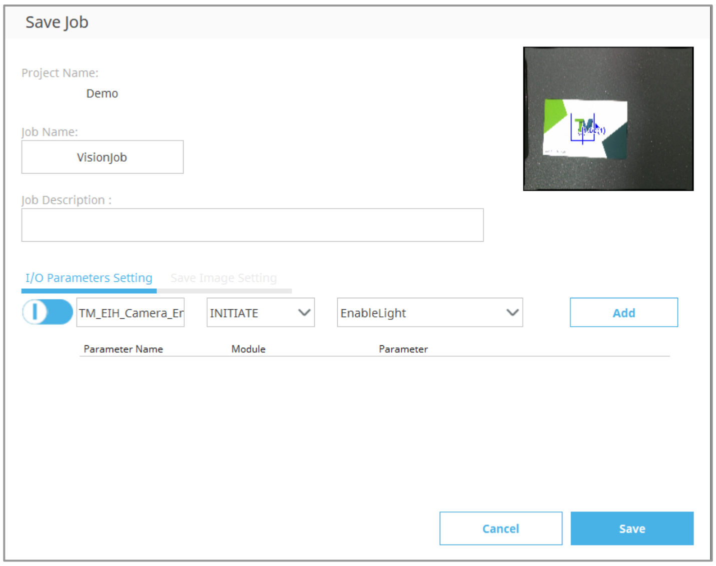


Figure 7: Set I/O Parameters Based on Results

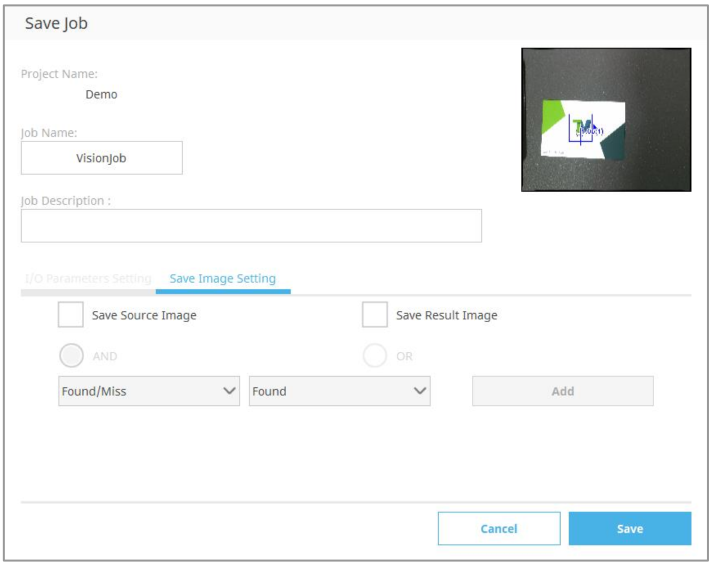


Figure 8: Save the Image Based on Results

Note

NOTE:
The name of the selected application will be put above the flow at the left as a label.

3.2.1 Object Positioning

Enter the TMvision Task Designer window and select Fixed Point to use this function. The fixed point function is designed for EIH and ETH for the robot to calculate and position objects with absolute coordinates by creating workspaces. Accuracy varies with that of workspace calibration. Refer to 2.2 Vision Base System Positioning Mode for details on creating workspaces. To set up a positioning task, configure the Motion and Camera steps of the Flow on the left side of the screen. Setting parameters are shown below:

Flow	Name	Function
Motion	Set Workspace	The robot's workspace must be set up first before other visual applications. The workspace includes one image-capture position.
	Vision Capture Point	If enabled, the robot returns to the image-capture position while operating. If disabled, visual recognition is performed at the robot's current position.
	Move to Capture Point	Move the robot to the position where it captures an image.
	Start at Initial Position	Check this to return the robot to its initial position before visual identification. Uncheck this and the robot will execute visual identification at the current position.
	Idle for Robot Stabilization	Set the length of time manually or automatically to have the robot self-adjust before taking pictures.
Camera	Adjust Parameters	These parameters include image size, shutter time (us), gain (dB), and focus for the built-in camera and white balance for extracted images. All the parameters feature an auto once function. Click Update to validate changes made.
	Auto Camera Parameters	All the camera parameters are automatically adjusted.
	Built-in Lighting	Toggle camera light on or off. Use the slider to set the brightness level
	Snap-n-go	Improve efficiency by concurrently taking snaps and keeping the flow going to save time for non-vision tasks that follow. After the image has been captured, the system will go to the next node and keep the image processing in the background from the flow. Note that when the processes after the Vision node require the result from the Vision node and the background image processing is still running, there will be conditions and returns as follows: ● If the next node requires the parameters of the result, such as the Boolean variables Done and Found generated by the Vision job, users will have to edit an If node for the system to determine how to proceed. ● If the next node is also a Vision node which includes a Vision base point or a Vision job, the flow will not continue until it is done with the last Vision node.
	Switch to Recorded Images	Use the internal TM SSD images for identification.

Table 6: Object Positioning Settings

After configuring the basic camera parameters, select the Find function at the top and select the pattern matching function as shown below. TMvision will use the framed shaped feature to find its alignment on the image and build the visual base on the object.

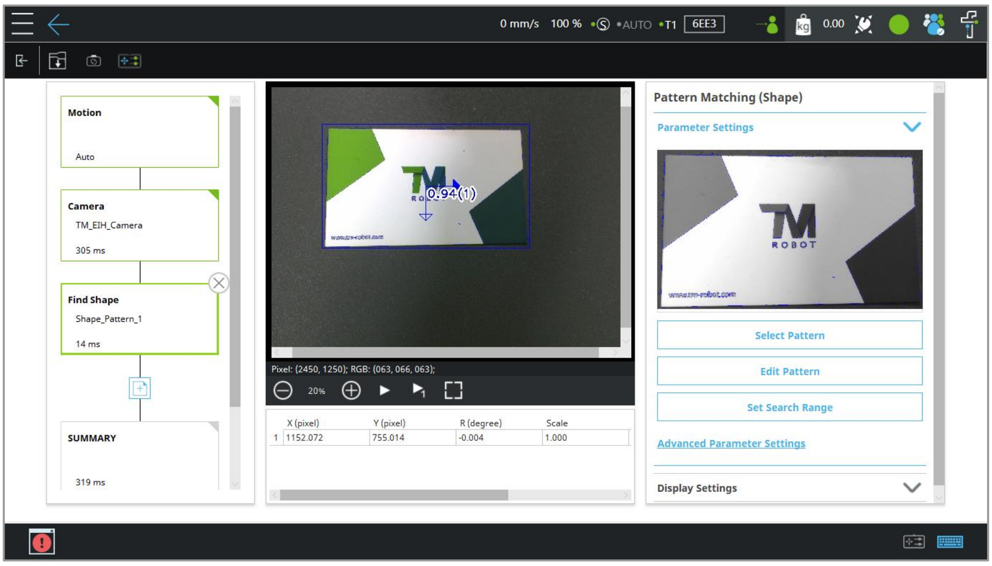


Figure 9: Object Positioning

Once the matching patterns have been determined, TMvision will compare the image in the current field of view against the one in storage to compute shape features and identify differences as well as give scores for matching. Users may set up thresholds to determine whether the two images are the same object.

Open **Summary** of the Flow on the left side of the screen, and users can find the repeatability of the current positioning task. TMvision collects 30 positioning data entries to calculate repeatability and display this accuracy result on a list. It then shows the positioning deviation after the 30 data entres on the oscilloscope below the list.

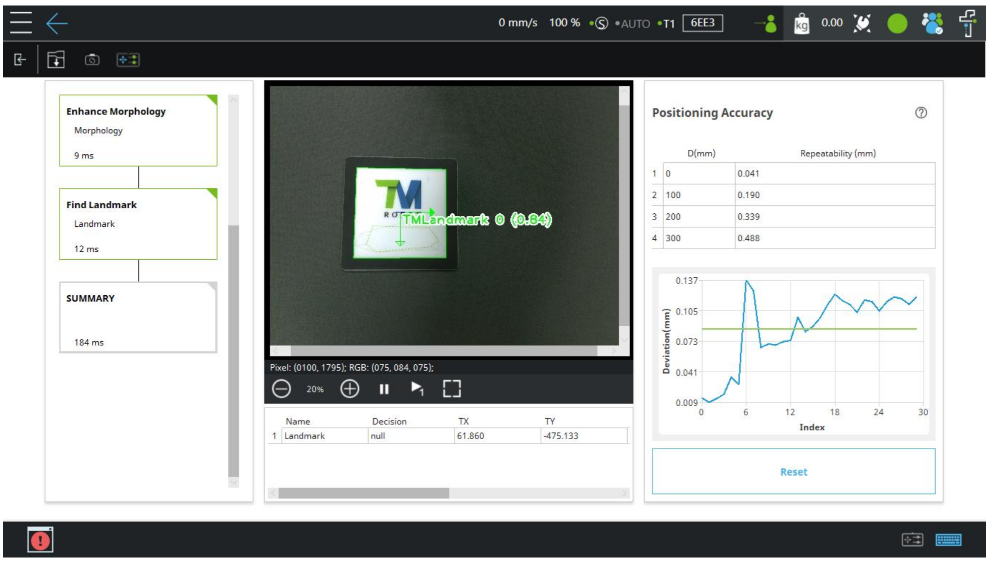


Figure 10: Positioning Repeatability

3.2.2 Landmark Positioning

Enter the TMvision Task Designer window to select and use the Landmark Positioning function. Users may run this function with the official OMRON Landmark. This is meant to build subsequent teaching points on the base system added by the OMRON Landmark.

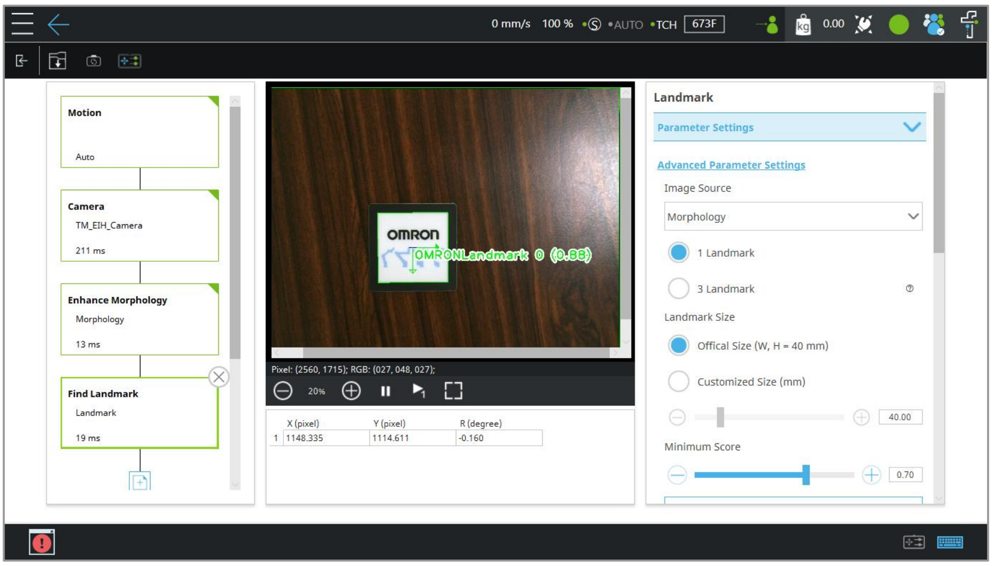


Figure 11: Landmark Positioning (1/2)

For points that were recorded on the robot base, users must teach all points again if the relative relationship between the robot and the object has changed. If the vision base system was created through Landmark and the aligning point is based on the previous vision base system, if the relative relationship between the robot and the object has changed, it only takes the vision node execution to update the Landmark vision base system.

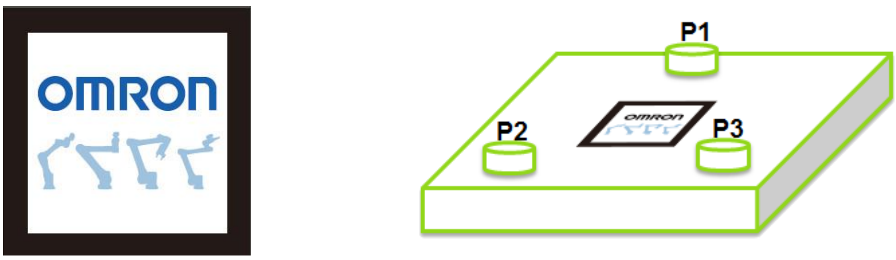


Figure 12: Landmark Positioning (2/2)

For an overview of the parameters for Motion and Camera of the Flow on the left side of the screen, refer to 3.2.1 Object Positioning. The Landmark Positioning parameter settings are as follows.

Name	Function
Image Source	Change image source
Name	Name the task
Minimum Score	Object can be identified only when the score of the detection result is higher than the minimum setting.
Set ROI	Once users click this button, a window will pop up where they can select a region from the image for detection.
Precise Detection (Cost Time)	Detect the Landmark more precisely but take an additional time of 30 to 50 ms.
Maximum Number of Objects	The maximum number of objects that can be detected in the image.
Sorted by	When the maximum number of objects is greater than 1, the outputs will be sorted according to the setting of this field.

Table 7: Landmark Positioning Settings

Note

NOTE:
Users can add Enhance, Identify, and Measure modules to the Landmark Positioning flows for the use of flexibility.

Open **Summary** of the Flow on the left side of the screen, and users can find the repeatability of the current positioning task. See 3.2.1 Object Positioning for details.

3.2.3 Servoing

Enter the TMvision Task Designer window and select Visual Servo to use this function. Visual servoing is only suitable for eye-in-hand. Alignment is achieved by getting continuously closer to the object's target coordinate on the image. The workspace does not need to be established. If the target angle has wide variations, use a calibration board to conduct level calibration during the initial alignment. The servoing time is determined by region of convergence and the robot movement path. This can be applied to situations where the relationship between the camera, workspace, and the robot can easily change due to changes in human action and the environment. After the level is calibrated, click Motion and Camera on the Flow to set up relevant parameters (see 3.2.1 Object Positioning for details). Users do not have to set up a workspace for servoing.

After the basic parameters have been set, confirm that the image is clear and can be seen. Select the Find function at the top and use the pattern matching function to match the pattern's shape feature in the selected frame.

Once the matching patterns have been determined, TMvision will compare the image in the current field of view against the one in storage to compute shape features and identify differences between them as well as give scores for similarity determination. Users may set up appropriate thresholds to determine whether the two images are of the same object.

Note

> **NOTE:**
> TMvision provides an easy feature editing function. If patterns selected contain unnecessary features users can click Edit pattern icon to modify features of the pattern.

Exit and return to the flow chart once completed. Users may set servoing target when there is at least one Find function in the in visual flow chart.

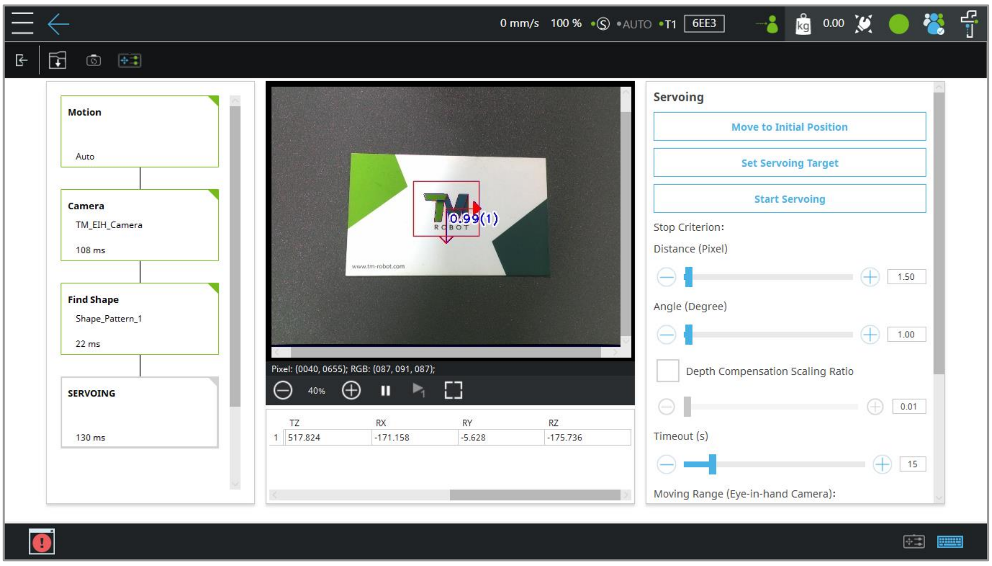


Figure 13: Visual Servoing

Parameters of the teaching page are described below:

Name	Function
Move to Initial Position	Move the robot to the initial position
Set Servoing Target	Determine servo target position by clicking the button and options below. (1) Use current position (2) Locate target at image center
Start Servoing	Click and hold to run the servoing process. Only save the results after successful servoing.
Stop Criterion	Use the sliders to configure the stop criteria of the **Distance**, the **Angle**, the **Depth**, and the length of **Timeout**. • Distance (Pixel): When features distances between the current object and the target model are less than or fall below the set value of the distance, it is judged to be a match. • Angle (Degree): When features angles between current and target object fall below the set value of the angle, it is judged to be a match. • Depth Compensation Scaling Ratio: Whether or not to perform depth compensation based on the Scaling value of the found object. • Timeout (s): Defaults to 45 seconds. Available from 10 ~ 45 seconds. Once triggered, the project goes to the flow where the condition fails.
Moving Range (Eye-in-hand Camera)	Use the sliders to configure the ranges of the limitations in the **Radius**, the **Distance**, and the **Rotation** angle of the camera. If the camera goes beyond the range, the system will take the fail route and leave the **Vision** node. • Radius in X-Y Plane (㎜): Stop the robot movement when the horizontal movement distance exceeds this value. • Distance in ± Depth (㎜): Stop the robot movement when the vertical movement distance exceeds this value. • Rotation in ± RZ (Degree): Stop the robot movement when the rotational movement distance exceeds this value.

Table 8: Parameters of the Teaching

After configuring the servoing target setting, click Start Servoing and press the (+) button on the robot stick to have TM Robot begin servoing the visual screen. Save the results once TMvision prompts servoing completed successfully.

3.2.4 Object-based Calibration

Object-based calibration is applicable to EIH only, which employs the difference in the robot servoing movement to calculate relative relationship between the object and the robot without workspace creation. If the positioning target angle has large variations, users must run the horizontal calibration with the calibration plate before determining the initial position. This function delivers high precision for objects with simpler shapes by building the fixed-point base system directly on the object to reduce the errors on the height measurements made with the calibration plate. When the horizontal calibration is completed, click Find function to select Pattern Matching(Shape) apart from Pattern Matching(Image), Blob Finder, Anchor, and Fiducial Mark Matching for TMvision to frame the shape.

Once the matching patterns have been determined, TMvision will compare the image in the current field of view against the one in storage to compute shape features and identify differences between them as well as give scores for similarity determination. Users can set thresholds to determine if the two images are the same object. Exit and return to the flow chart once completed. Once edited and there is at least one Find module in the visual flow chart, click Calibration to perform object-based calibration.

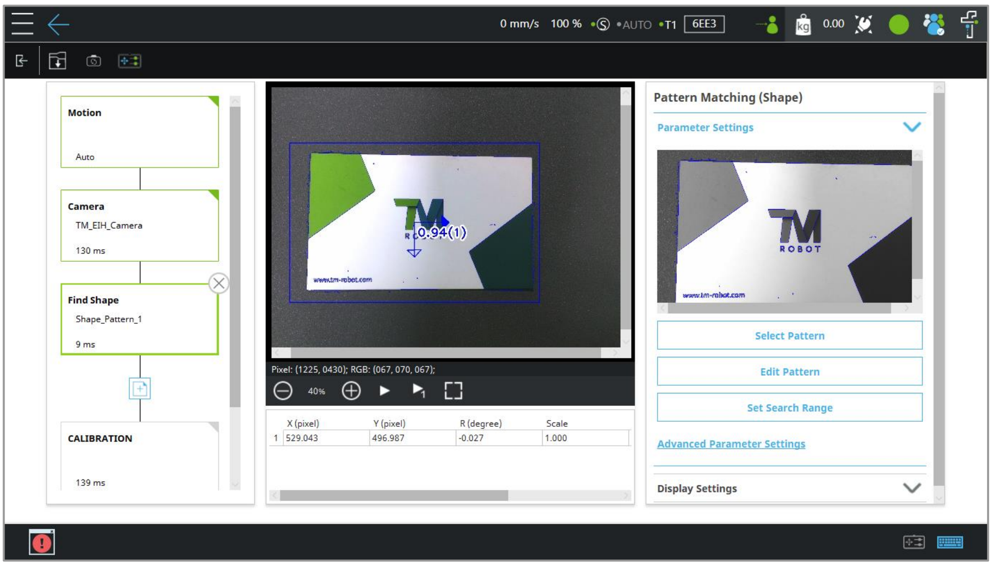


Figure 14: Object-Based Calibration

Name	Function
Move to Initial Position	Move the robot to the initial position.
Radius in X-Y Plane (㎜)	When the horizontal moving distance exceeds this value, stop the robot movement.
Distance in ± Depth (㎜)	When the vertical moving distance exceeds this value, stop the robot movement.
Start Calibration	Click and hold to the **+** button on the robot stick to servo the object. The robot will move four times to place object at each of the four corners of image field to complete the action. Only save the file after the robot successfully completes these actions.

Table 9: Object-Based Calibration Settings

3.2.5 Smart-Pick

Smart-Pick lowers the threshold of using TMvision by adopting the Vision button to perform a step by step and simple-to-use vision job teaching process, and users can use OMRON Landmark to achieve a fixed point vision job without the calibration plate. Smart-Pick applies to the stack of boxes, pick and place with trays (low precision requirements), and applications with extra compensations (force sensor, gripper, or object restricted position.) Using Smart-Pick for applications with 1~2 ㎜ accuracy is recommended.

> **NOTE:**
> To switch the Vision button at the end of the robot to Smart-Pick, go to **TMflow** > ☰ > **Configuration** > **End Button** > **Vision Button** and check **Smart-Pick**.

Users can start using Smart-Pick by navigating to **Task Designer** > **Please select an application to start** and click the **Smart-Pick** icon or press the Vision button at the of the robot if switched to Smart-Pick.

Steps to use Smart-Pick

1. Put OMRON Landmark in the vision of the robot. Move the robot if necessary. Click **NEXT** to automatically adjust shutter time (us), gain (dB), white balance, and focus based on the current location.
2. If the automatic adjustment does not fit, click **Camera Parameters** to adjust manually. If the landmark is not clear enough, enable **Lighting** and adjust the lighting level (by dragging the slider below to the left to reduce the lighteness or to the right to increase the lightness) to compensate for any loss of light.
3. Half-push the Enabling Switch while holding the Play button on the robot stick to perform tilt-correction. Click **Next** when done and setting the landmark base as the work platform of the object.
4. Click **Camera Parameters** if necessary and capture the image of the background without the object. Click **Next**.
5. Capture the image of the object with the background.
6. Adjust **Region of Interest** parameters for the best outcome. Click **Select Pattern** to scale ROI down.
7. Adjust the matching parameters or use **Edit Pattern** to edit the feature of the object. **Set Search Range** of the object location, rotation, and scale in the image. To apply extra functions such as Enhance, click **Transform Into a General Vision Job** to save the job without the Smart-Pick feature. (Once the image is transformed, there is no way to revert the Smart-Pick feature.)
8. Click **Save** to save the job. The default job name goes by **SmartPick_** with a sequence number. Users can use the Vision button as **Done**, **Save**, and **Yes** in this step.

Note

NOTE:

- The next time users open the save Smart-Pick job, the system will prompt users to transform into a general vision job or not.
- Once opened as the Smart-Pick job, the system will prompt users to select which step to start with. Whichever step users take, the system will prompt users to return to the initial position with the robot stick and the after steps in the last saved setting will be cleared.

3.2.6 AOI

Enter the TMvision Task Designer and select AOI to use this function. The AOI identification is applicable to EIH or ETH to read Barcode and QR code, Color Classifier, and String Match without workspace and base system output. To identify a barcode, make sure there is only one clear and readable barcode in the framed region. To set up an AOI task, configure the parameters of Motion and Camera of the Flow on the left side of the screen. The parameters are shown as below:

Flow	Name	Function
Motion	Vision Capture Point	If enabled, the robot returns to the image-capture position while operating. If disabled, visual recognition is performed at the robot's current position.
	Move to Capture Point	Move the robot to the image-capture position
	Rest Capture Point	Reset the robot's image-capture position. Users can decide whether to do tilt correction for this position. If a workspace has been set up, the image-capture position must be level with the workspace when it is being reset. Otherwise, positioning accuracy will decline.
	Idle for Robot Stabilization	Set the length of time manually or automatically to have the robot self-adjust before taking pictures.
Camera	Adjust Parameters	These parameters include image size, shutter time (us), gain (dB), and focus for the built-in camera and white balance for extracted images. All the parameters feature an auto once function. Click Update to validate changes made.
	Auto Camera Parameters	All the camera parameters are automatically adjusted.
	Built-in Lighting	Toggle camera light on or off. Use the slider to set the brightness level
	Snap-n-go	Improve efficiency by concurrently taking snaps and keeping the flow going to save time for non-vision tasks that follow. After the image has been captured, the system will go to the next node and keep the image processing in the background from the flow. Note that when the processes after the Vision node require the result from the Vision node and the background image processing is still running, there will be conditions and returns as follows: ● If the next node requires the parameters of the result, such as the Boolean variables Done and OK generated by the Vision job,

		users will have to edit an If node for the system to determine how to proceed. If the next node is also a Vision node which includes a Vision base point or a Vision job, the flow will not continue until it is done with the last Vision node.
	Switch to Recorded Images	Use the internal TM SSD images for identification.

Table 10: AOI Settings

After setting the basic parameters, choose the pattern matching function in the Find function at the top to proceed with matching. The identification is for a specific spot only, not for the entire field of view. Users can use the Find function to adjust the search range to find the object feature. Once the object feature is found, the object's barcode can be accurately identified. The barcode identification will output the identification result. Use the Display node to confirm the accuracy of the barcode.

In an AOI task, judgement conditions can be created for all vision modules except for Enhance. If no judgment condition is created or a judgement condition is met for a step of the Flow on the left side of the screen, the condition is considered as OK and the step is displayed in a green box. If a judgement condition is not met for a step, the condition is considered as NG and the step is displayed in a red box. If the judgement conditions for all steps of a Flow are OK, the Inspection node outputs an OK. If one or more steps have an NG condition, the Inspection node outputs an NG.

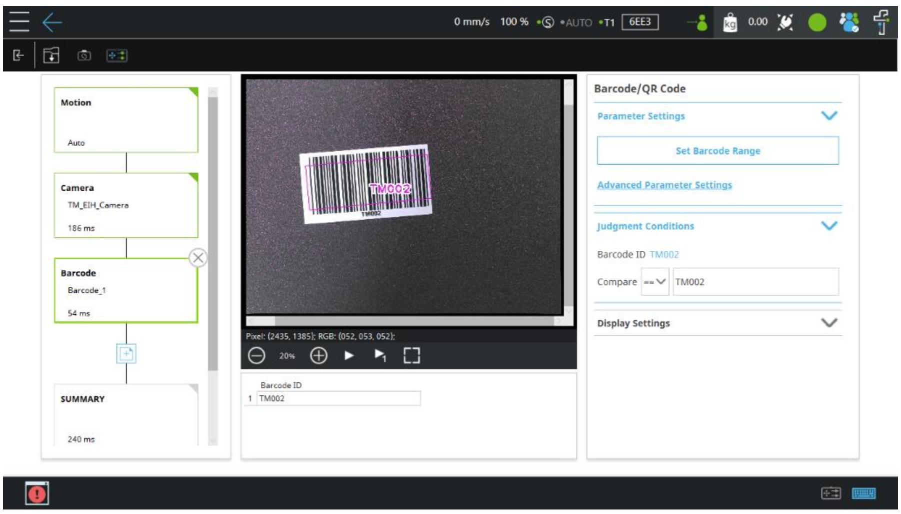


Figure 15: Judgment Condition

At the end of the vision flow chart, users can adjust the reference point of the position output information with the Bias settings.

Name	Function
Manual Adjustment	Manually drag the Bias point to the target position.
Delta X (pixel)	Move the Bias point in the X direction.
Delta Y (pixel)	Move the Bias point in the Y direction.
Delta R (degree)	Rotate the Bias point about its initial position.
Unit of Distance	The pixels can be converted to millimeters by the calibration plate or OMRON Landmark (for reference only).

Table 11: Bias Settings

3.2.7 Vision IO

Enter the TMvision Task Designer window and select Vision IO to use this function. When an obvious change occurs in the picture, the difference before and after the change can be used to determine whether a change has occurred to the Sensing Window. The Vision IO module views the camera as an IO module, and continuously monitors a specific area in the screen. When the area shows significant change in content, a trigger signal is sent to TMflow.

Startup method:

Task Designer → Vision IO

In comparison to the previous vision tasks in the flow, when selecting Vision IO at startup, users can set up in the prompt as shown in the left of the figure below.

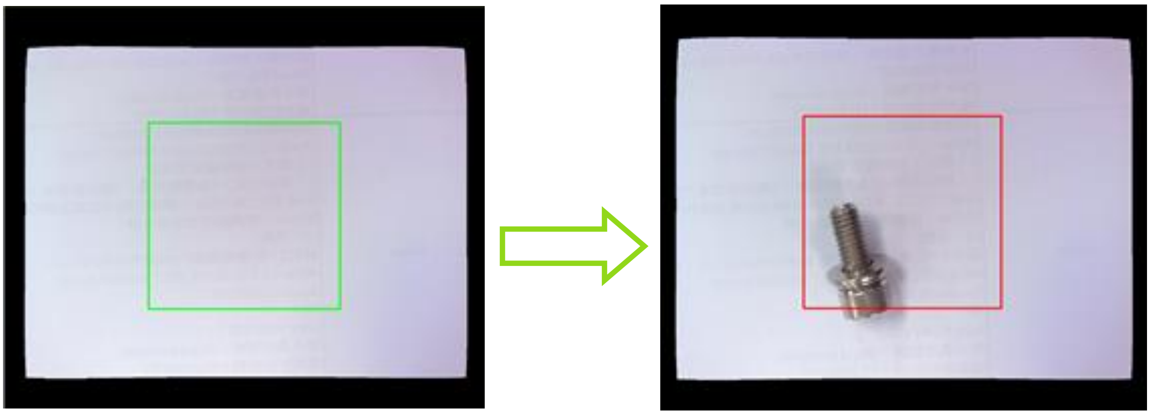


Figure 16: Vision IO

Name	Function
TimeOut	Set the time waiting for Vision IO. If the IO is not activated within the time limit, the process exits through the Fail path.
Set Sensing Window	Set a region in the live video as an area to monitor. After the setting is completed, if the level of variations goes over the threshold, it means that triggered event occurs.
Threshold	Trigger event sensitivity: The lower the threshold, the more sensitive.

Table 12: Vision IO Settings

3.3 Function list

The TM Robot Vision Designer provides five module functions: Enhance, Find, Identify, and Measure.

3.3.1 Enhance

Enhance provides multiple functions to enhance image features and improve successful project identification in special application environments.

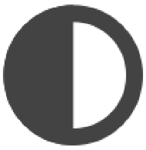
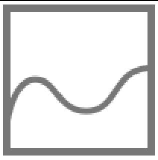
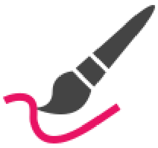
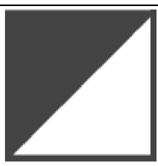
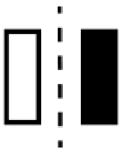
Module		Function
Contrast Enhancement		Adjust image contrast.
Color Plane Extraction		Obtain specific colors (such as red, blue, or green) or saturation.
Image Mask		Hide part of an image
Smoothing		Filter out noise and increase the image's smoothness.
Morphology		Erode, dilate, patch, or open the image.
Thresholding		Transform a raw image into a black and white one.
Flip		Flip the image.

Table 13: Function List – Enhance

3.3.1.1 Contrast Enhancement

Adjust image brightness and contrast to enhance the contrast between object and background to improve accuracy of object detection.

the contrast between the region of interest (ROI) against the background is poor, users may enhance it with this module to improve the success rate of object comparison. Users are advised to maximize differences between brightness of foreground and background by adjusting the contrast value. Then adjust the gamma value to brighten the bright area and dim the dark area.

Enhance settings	Function
Image Source	Switch among source image modules
Contrast	Adjust contrast. Adjust in the negative direction for a negative image.
Brightness	Adjust brightness
Gamma	Adjust image gamma value
Reset	Reset parameters
Color Plane	Select specific color plane for adjustment.
Lookup Table	Conversion curve for the input and output
Histogram	Image's histogram

Table 14: Function List – Enhance (Contrast Enhancement)

3.3.1.2 Color Plane Extraction

Users can extract a specific color plane from an image or convert the color plane from RGB space to HSV space. With the emphasis on the different color planes of the objects and the backgrounds, users can choose the appropriate color plane to increase the contrast between the object and the background and improve the detection accuracy.

The object search module basically operates in a grayscale space. Imported color images are converted into grayscale. Users may use this module to convert images into color space with the best foreground/background difference to improve object identification.

Enhance settings	Function
Image Source	Switch among source image modules
Color Plane	The color plane will evaluate: - Gray - Red - Green - Blue - Hue - Saturation - Value
Histogram	Image's histogram

Table 15: Function List – Enhance (Color Plane Extraction)

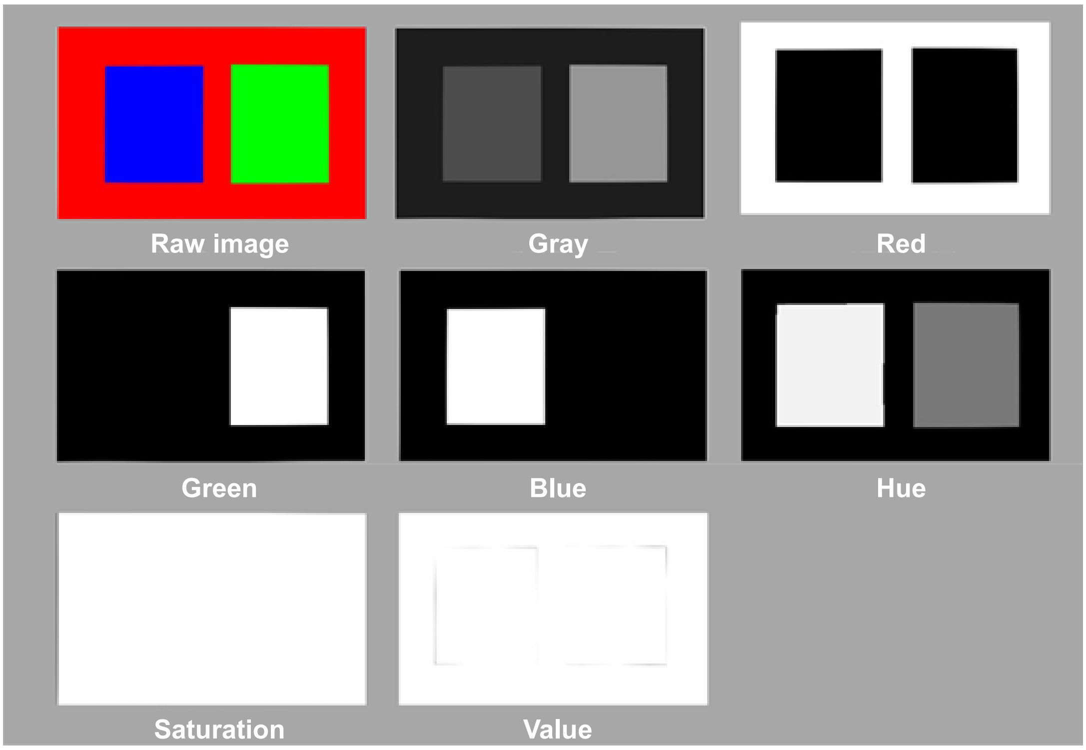


Table 16: Function List – Enhance (Color Plane Extraction – Color Plane)

3.3.1.3 Image Mask

This function hides part of an image.

Enhance settings	Function
Image Source	Choose the source image.
Name	Name the Enhance task.
Set Mask	Select a region to be masked.
Select Mask Color	Select a masking color.
Fill the inside of the mask	Hide the inside of the masked region.
Fill the outside of the mask	Hide the outside of the masked region.

Table 17: Function List – Enhance (Image Mask)

3.3.1.4 Smoothing

Enhance settings	Function
Image Source	Switch between source image modules
Filter Type	Select filter type: - Mean Filter - Gaussian filter - Median filter
Mask Size	Regarding mask size: larger mask size results in a smoothing effect in a greater region where the median filter will only make width adjustable.

Table 18: Function List – Enhance (Smoothing)

3.3.1.5 Morphology

Morphology computing is often applied to binarized images, applying closing or opening effects to the current image for noise removal or connecting broken foreground objects.

Enhance settings	Function
Image Source	Switch between source image modules.
Operation Type	Dilation: Expand the white area. Erosion: Erode white areas. Opening: Erode the white area before dilating it to open connected weak sides or remove broken fractures. Closing: Dilate the white area before eroding it to patch up broken faces or voids. Gradient: Subtract the image after erosion from the image after dilation to extract the edge area.
Structuring Element	Options: ● Rectangle ● Cross ● Ellipse
Element Size	The larger the element size the greater the calculation range.
Iteration	Number of repeated operations

Table 19: Function List – Enhance (Morphology)

3.3.1.6 Thresholding

Set the gray value of pixels larger than the upper threshold to gray value upper limit and pixels smaller than the lower threshold to gray value lower limit, and simplify the color scale of the image.

Enhance settings	Function
Image Source	Switch between source image modules
Threshold Type	Binary: If higher than threshold, set as white. If lower, then set as black. Binary (Inverted): Set to black if higher than threshold. Otherwise, set to white. Truncated: If higher than threshold, set equal to threshold. To Zero: If lower than threshold, set as zero. To Zero (Inverted): If higher than threshold, set as zero.
Automatic Thresholding	The binary threshold is automatically determined by the system.
Thresholding value	Manually adjust the binary threshold.

Table 20: Function List – Enhance (Thresholding)

3.3.1.7 Flip

This function can be used to flip the image.

Enhance settings	Function
Image Source	Choose the source image
Flip Direction	Options: ● Vertical ● Horizontal

Table 21: Function List – Enhance (Flip)

3.3.2 Find

Module	Function	Output (floating point)
Pattern Matching (Shape)	Locate an object in the image based on its geometrical features.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
Fiducial Mark Matching	Use the two obvious features on the object for matching.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
Anchor	Change home coordinates of object detection by manually adjusting the anchor point.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
Pattern Matching (Image)	Locate an object in the image based on its pixel value distribution features.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
Blob Finder	Locate an object by the color difference between the object and the background.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
External Detection	Use a remote computing platform with the protocol of HTTP for object detecting and positioning.	Relative to coordinates X, Y, rotation angle R of image home (upper left) and object label.
Image Alignment	Shift and rotate the entire input image based on the detected shape pattern to place the pattern at the center of the image.	Relative to coordinates X, Y and rotation angle R of image home (upper left).

Table 22: Function List – Find

3.3.2.1 Flow

The left side of the vision programming flow chart shows the computing flow of vision tasks. The highlighted bold frame indicates the process now in focus. The green frame indicates the process functioned successfully, and the orange frame indicates the process functioned unsuccessfully.

IMPORTANT

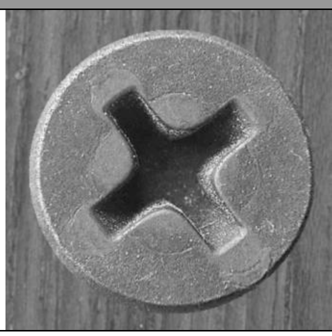
IMPORTANT:
If any of the processes in a flow are orange, the flow cannot be saved.

3.3.2.2 Pattern Matching(Shape)

The function uses the geometrical shape of the object as its pattern model and matches it to the input image to find the object in the image. It supports variations due to object rotation and dimension. It is best for objects with rigid profiles.

Name	Function
Image Source	Switch among source image modules
Name	Name the task.
Select Pattern	When this function is clicked, the current image will pop up. Users can select an object in the image and choose one out of three patterns. These patterns, displayed from left to right, are respectively the entire shape of the main object, the entire shape of the selected area, and the outer shape of the main object (see Table 24 for details).
Smart Pattern Learner	To create fast visual extract tasks with process learning the pattern model. Step 1: Add object search module (shape), click "Smart Pattern Learner". Step 2: Shoot background. Step 3: To shoot a workpiece, press “Next” to identify the target object once it gets located. Step 4: Adjust Threshold, Inner Distance, and Outer Distance. Step 5: Press “Next” to exit the Smart Pattern Learner.
Edit Pattern	Click and the edit window pops up to edit shape feature of the object. (The edit tools are listed in the table below.)
Set Search Range	Set the location, rotation, and scale of the range to search.
Number of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Minimum Score	Object can be identified only when the score of the detection is higher than the minimum setting.
Maximum Number of Objects	The maximum number of objects that can be detected in the image.
Sorted by	When the maximum number of objects is greater than 1, the outputs will be sorted according to the setting of this field.
Directional Edge	Select whether the shape edge is directional.

Table 23: Function List – Find (Patten Matching (Shape))

Pattern


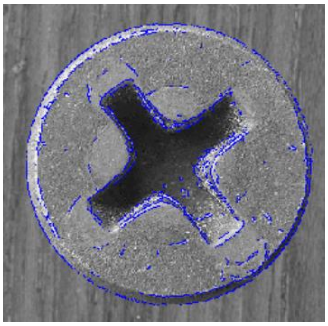
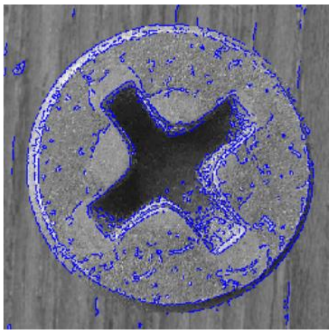
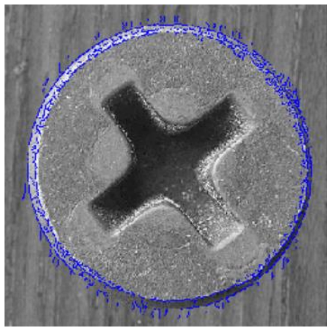
Entire shape of the main object	Entire shape of the selected area	Outer shape of the main object
		

Table 24: Select a suitable shape pattern

Tool	Function
Zoon in	Make the image appear larger
Zoon out	Make the image appear smaller
Undo	Undo a previous edit
Redo	Recover a previous edit
Eraser	Remove an edit.
Pen	Edit the image using a pen.
Line	Edit the image using a line.
Rectangle	Edit the image using a rectangle.
Ellipse	Edit the image using an ellipse.
Polygon	Edit the image using a polygon.
Auto Feature Extraction	Edit the image automatically, with all previous edits reset.
Auto Fit	Fit a line, rectangle, or ellipse with the image.

Table 25: Edit Toos for Patten Matching (Shape)

IMPORTANT

IMPORTANT:

- Search range: Set rotation angle smaller for symmetrical objects , e.g. rectangles (-90~90), squares (-45~45), and circles (0~1).

- The number of Pyramid Layers is directly linked with speed of pattern matching. The algorithm matches layers from top down. As an additional layer is added, the pixel resolution is halved, but the search speed is up. The frequently used value for the layers falls between 3 and 5. Users may set up according to characteristics of pattern edge feature. Fewer layers will preserve more feature details, and more layers result in less processing time.
- Smaller minimum scores reduces omissions from judgments at the cost of more misjudgments. Frequently used values fall between 0.5 and 0.7.

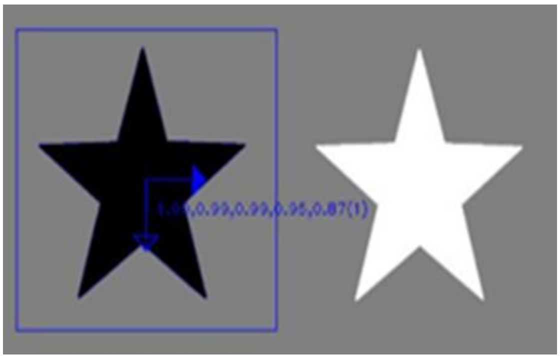
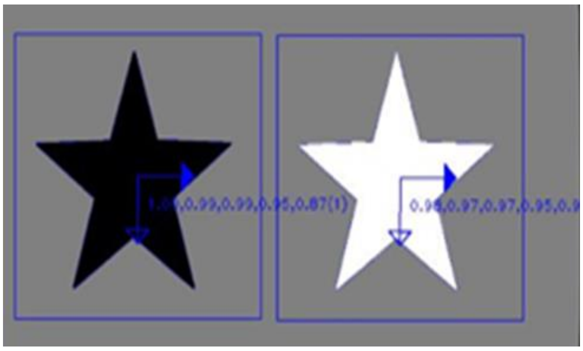
Pattern	
	
Check Directional Edge	**Uncheck Directional Edge**
	

Table 26: Function List –Find (Patten Matching (Shape))

NOTE:
The pattern matching algorithm determines matching of objects based on strength and directions of object edges. Edge direction refers to whether the edge is from light to dark or from dark to light. When directional edge is checked, the direction of the pattern's edges will influence the identification result (star on the left side gets detected). Otherwise, both stars will be detected.

3.3.2.3 Fiducial Mark Matching

The Fiducial Mark Matching function is designed to detect and position the two positioning points on PCBs. It is fast and reliable. However, this function has a smaller search range and lower success rate when the objects zoomed or rotated. For example, this function is suitable for PCB operation, which features little shift in feeding position and requires quick and accurate positioning.

Name	Function
Image Source	Switch among source image modules
Name	Name the task.
Set Fiducial Marks	Set two anchor points on the image in sequence
Set Search Range	Set search range of the two anchor points on the image in sequence
Threshold	Set matching threshold
Similarity Metric	Users can pick "Correlation Coefficient" or "Absolute Difference" as the most appropriate measuring method. The former has a slower speed, but is tolerant of ambient light differences, and the light and shadow changing ability is stronger.

Table 27: Function List – Find (Fiducial Mark Matching)

3.3.2.4 Anchor

The anchor function sets the initial position and the orientation of the object base system. Users can find objects with a Find module, and the default base system of the objects is marked with blue arrows, which is for users to anchor a point at the end of the flow. Setting the initial position to the top left vertex and parallel to the black frame will orient the vision base with the anchor.

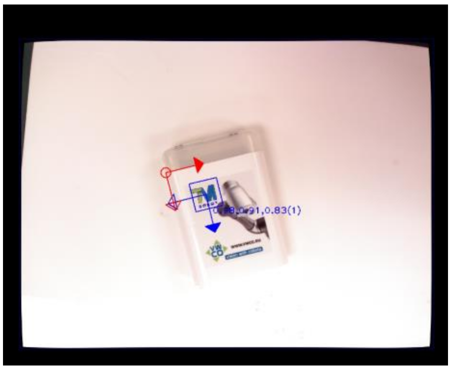


Figure 17: Anchor

Note

NOTE:
The hollow arrow denotes the X direction, and the solid arrow denotes the Y direction.

Name	Function
Image Source	Switch among source image modules
Name	Name the task.
Manual Adjustment	Manually drag the anchor point to the target position.
Shift in X (pixels)	Move the anchor in the X direction.
Shift in Y (pixels)	Move the anchor in the Y direction.
Rotation (degree)	Rotate the anchor about its initial position.

Table 28: Function List – Find (Anchor)

3.3.2.5 Pattern Matching(Image)

This function uses the image of the target object itself as its pattern model and matches it to the input image to position the object in the image. It supports variations due to object shift and rotation. Differing from shape pattern matching, this function does not support dimension changes and may take a long time to compute. It may be employed when the workpiece lacks visible features or has fuzzy edges.

Name	Function
Image Source	Switch among source image modules
Name	Name the task.
Select Pattern	After selection, this image will pop up. Users can select the object in the image.
Set Search Range	Set the location, size, and rotation of the range to search.
Number of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Minimum Score	If the score of the detection result is higher than this minimum score, the system will identify this as the object.
Maximum Number of Objects	The maximum number of objects that can be detected in the image.
Similarity Metric	Users can pick "Correlation Coefficient" or "Absolute Difference" as the most appropriate measuring method. The former has a slower speed, but is tolerant of ambient light differences, and the light and shadow changing ability is stronger.
Sorted by	When the maximum number of objects is greater than 1, the output result will be sorted according to the setting in this column.

Table 29: Function List – Find (Patten Matching (Image))

IMPORTANT

IMPORTANT:

- Search range: Set rotation angle smaller for symmetrical objects , e.g. rectangles (-90~90), squares (-45~45), and circles (0~1).
- The number of Pyramid Layers are directly linked with speed of pattern matching. The algorithm matches layers from top down. As an additional layer is added, the pixel resolution is halved, but the search speed is up. The frequently used value for the layers falls between 3 and 5. Users may set up according to characteristics of pattern edge feature. Fewer layers will preserve more feature details, and more layers will reduce processing time.
- Smaller minimum scores reduces omissions from judgments at the cost of more misjudgments. Frequently used values fall between 0.5 and 0.7.

3.3.2.6 Blob Finder

Differing from detecting objects of fixed geometry by pattern matching, objects without fixed geometry should use this function for detection.

Name	Function
Image Source	Switch among source image modules
Name	Name the task.
Set Search Range	Set effective detection range
Color Plane	Choose RGB or HSV as the color space
Extract Color	Click and enclose color of ROI on image.
Red, Green, Blue	Distribution range of ROI color
Area Size	To set up the area of foreground scope: Objects with foreground pixels outside of this area will be discarded.
Maximum Number of Objects	The maximum number of objects that can be detected in the image.
Sorted by:	When the maximum number of objects is greater than 1, the outputs will be sorted according to the setting of this field.
Ignore Rotation	Ignore the rotation angle of any object detected (the value of this angle is output as 0).

Table 30: Function List – Find (Blob Finder)

3.3.2.7 External Detection

External Detection uses a remote computing platform with the protocol of HTTP for object detecting and positioning.

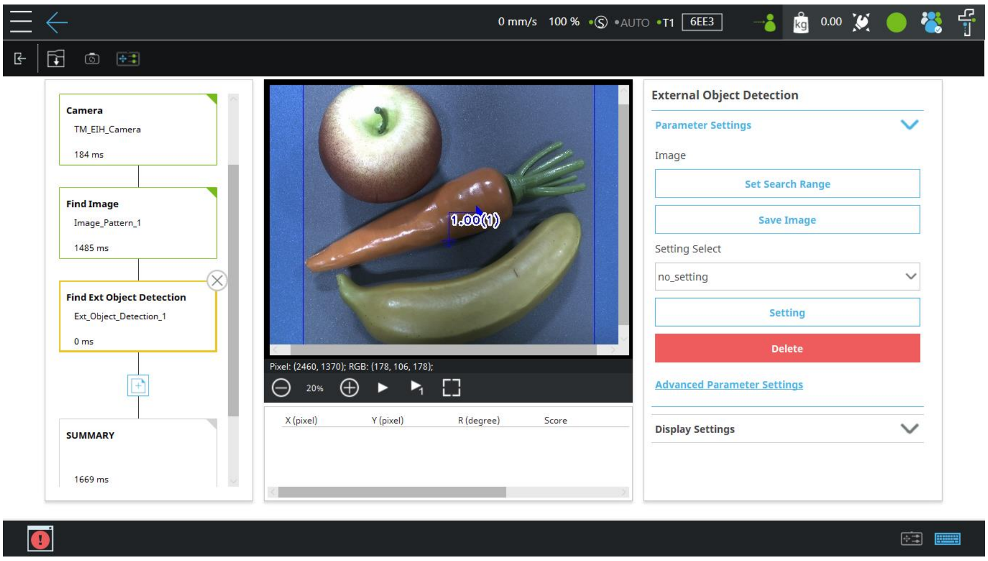


Figure 18: External Detection (1/2)

Use the dropdown box below **Image Source** to select the source of the image. In the **Name** field, input the name for the detection process. Use **Set Search Range** button to set regions of object searching in the image. Use the dropdown box below **Setting**

Select to select configured HTTP parameters. The default goes without any selected model. Use **Setting** button to modify parameters for the respective model. Parameters in **HTTP Setting** and **Inference POST** are **Get**, **URL**, **Post Key**, **Value**, **jpg**/**png**, **Timeout(ms)**, **Setting name**. A warning message prompts if **HTTP Setting** is overwritten with the same **Setting name**. No identical individual **Setting Name of HTTP Setting** is allowed in one TM Robot.

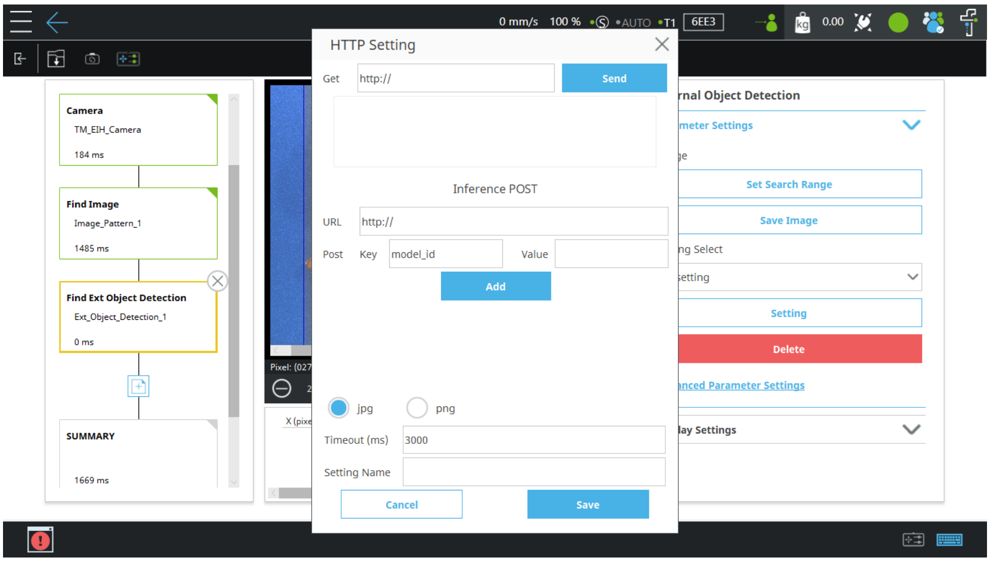


Figure 19: External Detection (2/2)

Note

NOTE:

As a network communication protocol, HTTP works only when the connection is established. External Detection uses POST cmd on every detection to send pictures to the HTTP server by the configured URL. The HTTP server inspects the pictures by breaking up the relevant key-values and returns the result in the JSON format packets to TM Robot.

Protocol Define of Find - External_Detection

1. Image size : decided by TM vision image source
2. Image format : jpg or png
3. box_cx: center x, true location on source image, float
4. box_cy: center y, true location on source image, float
5. box_h: height, int
6. box_w: width, int
7. label: object name show on TMvision, string
8. rotation: clockwise, float
9. score: between 0.000 and 1.000, float
10. Our Detection module will output the `annotations` value if the `message` value is "success", or the error message otherwise.

Example

1. image: Image.jpg
2. curl example: curl -X POST "http://127.0.0.1:4585/api/DET" -F image=@"C:/Image.jpg" -F "model_id=test"
3. JSON response


```
{
    "annotations" : [
        {
            "box_cx" : 150,
            "box_cy" : 150,
            "box_h" : 100,
            "box_w" : 100,
            "label" : "apple",
            "rotation" : -45,
            "score" : 0.964
        },
        {
            "box_cx" : 550,
            "box_cy" : 550,
            "box_h" : 100,
            "box_w" : 100,
            "label" : "car",
            "rotation" : 0,
            "score" : 1.0
        },
        {
            "box_cx" : 350,
            "box_cy" : 350,
            "box_h" : 150,
            "box_w" : 150,
            "label" : "mobilephone",
            "rotation" : 135,
            "score" : 0.886
        }
    ],
    "message" : "success",
    "result": null
}
```


Drag the slider below **Min. Score** to remove objects below the minimum score. Drag the slider below **Max. Num. of Objects** to set the maximum available number of object to display. Use the dropdown box below **Sorted by** to select the sorting method of object priorities.

The sorting method goes by **Score**, **Left to Right**, **Right to Left**, **Top to Bottom**, **Bottom to Top**, **Nearest to Image Center**, **Nearest to Top-Left**, **Nearest to Top-Right**, **Nearest to Bottom-Left**, and **Nearest to Bottom-Right**. Use **Save Current**

Image button to save the inspected region of the image. When the system cannot find any path set for saving the image, it saves the image to a root directory of a USB drive labeled “TMROBOT.” The image is saved as yyyy-MM-dd-HH-mm-ss_zzz.jpg in the following path:
[drive_letter]:\project_name\job_name\yyyy-MM-dd\object_name\.

When the vision job of TMflow comes to an end, the module External Detection outputs the position and the label of the detected object.

3.3.2.8 Image Alignment

This function uses an object’s geometric shape to create a pattern for the object, compares the pattern with the input image to determine the object’s position in the image, and shifts and rotates the entire image to place the pattern at the center of the image.

Name	Function
Image Source	Change image source.
Name	Name the task.
Select Pattern	After selection, this image will pop up. Users can select the object in the image.
Edit Pattern	Click and the edit window pops up to edit shape feature of the object.
Set Search Range	Set the location, rotation, and scale of the range to search.
Num. of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Min. Score	Object can be identified only when the score of the detection is higher than the minimum setting.
Directional Edge	Select whether the shape edge is directional.
Shift of X (pixel)	Set the extent of shift along the x direction after an object’s position is compensated for in the image.
Shift of Y (pixel)	Set the extent of shift along the y direction after an object’s position is compensated for in the image.
Rotation (degree)	Set the extent of rotation after an object’s position is compensated for in the image.

Table 31: Function List – Find (Image Alignment)

3.3.2.9 One Shot Get All

This function creates multiple sets of independent processes for one visual task by taking one shot to output multiple-objects and multiple-sets of identification results to save a lot of repetitive computing time as only one shot is required.

This feature supports fixed-point positioning, AOI modules, and ETH "Pick'n Place" module.

Step 1: Create a visual object search process module such as **Find** > **Pattern Matching (Shape)**.

Step 2: Select the Camera process, then click **+** to add another visual object search process.

Step 3: Click **Advanced,** then select Parallel to add independent search processes in parallel to each other, or Cascade to add process modules one after another.

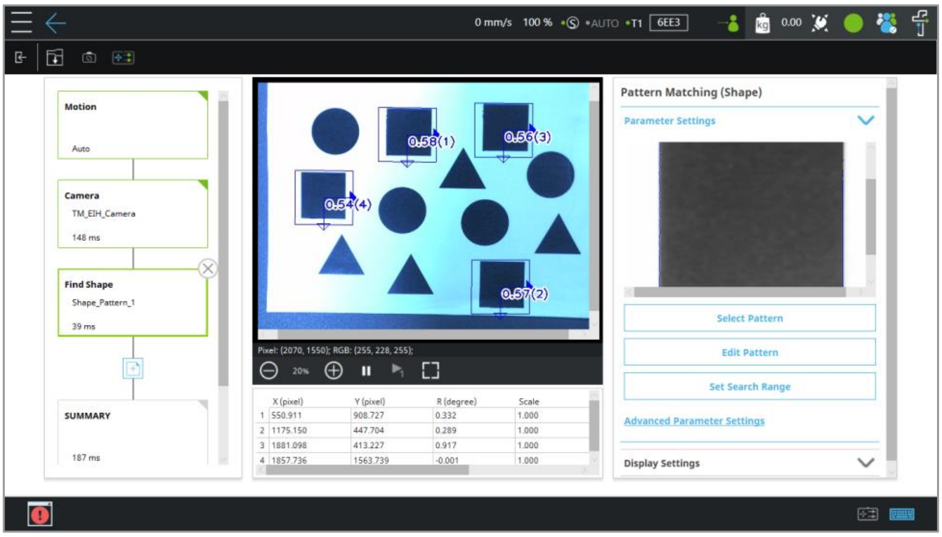


Figure 20: One Shot Get All (1/4)

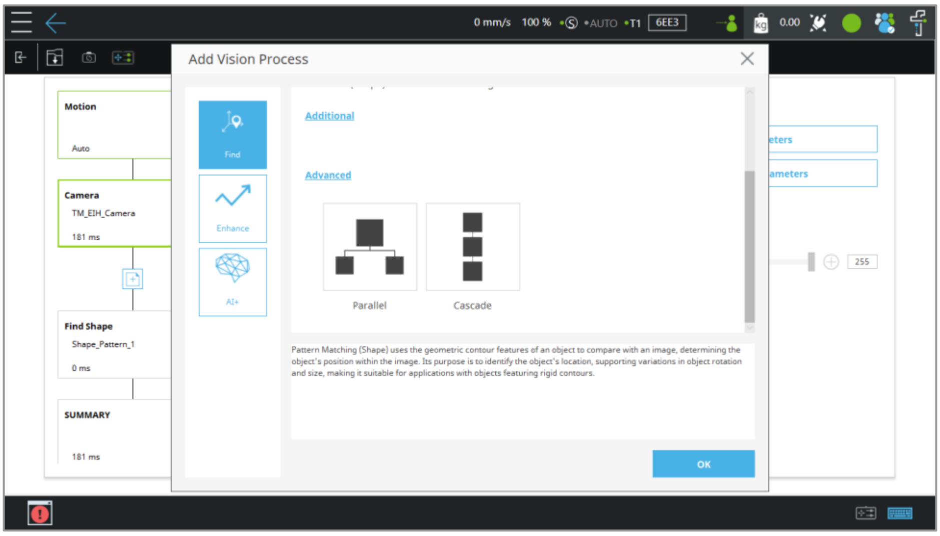


Figure 21: One Shot Get All (2/4)

Step 5: Save the vision job.

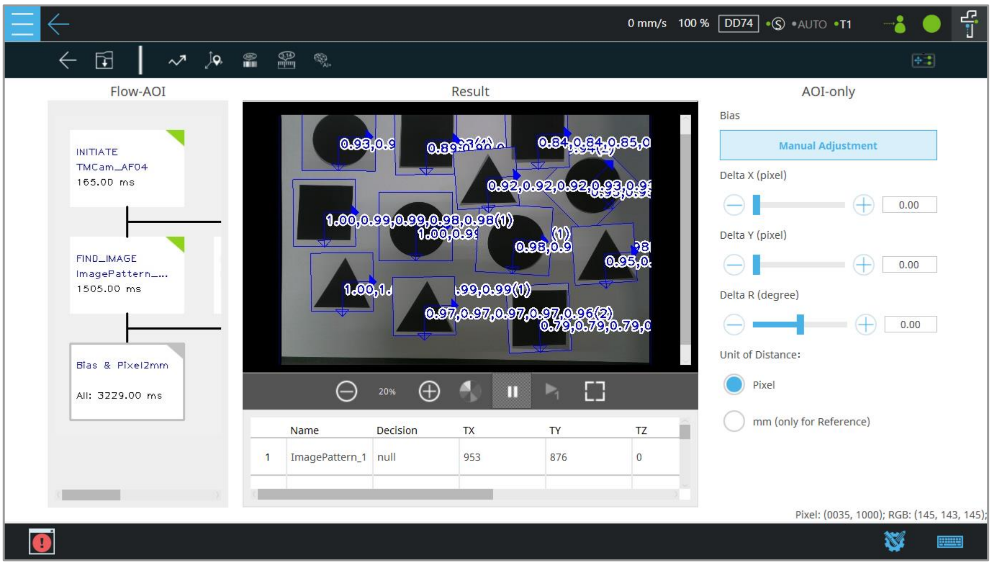


Figure 22: One Shot Get All (3/4)

The vision job generates N sets of the vision base after finished, they generate, and each set of the vision base comes with variables var_MAX and var_IDX as the maximum number of the object searching and the current base index respectively.

By taking one single shot to capture multiple objects, objects can be picked and placed in sequence with batches. As shown below, after passing the vision node, the individual maximum number of the object searching and the individual current base index will be reset. As one job finishes, the base index variable var_IDX proceeds the action +1 with the SET node to denote a job completed and compares with var_MAX in the IF node. If var_IDX equals var_MAX, it means the job is done for that object and will search for the next object in order until all jobs are done.

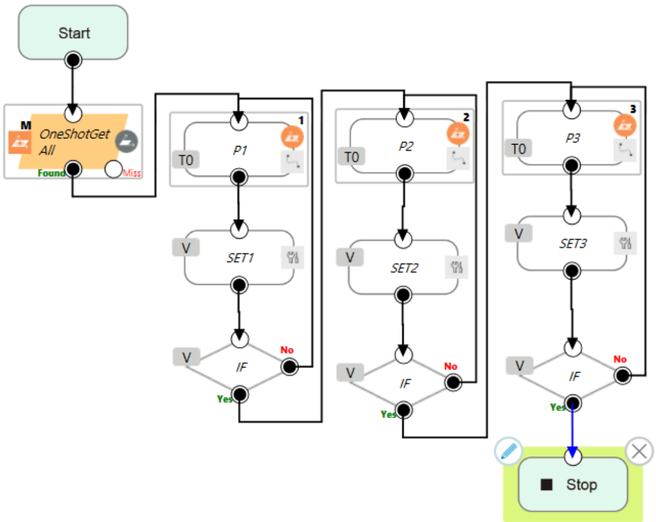
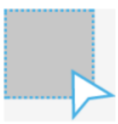


Figure 23: One Shot Get All (4/4)

3.3.3 Identify

Traditional manual inspection can lead to errors caused by personnel fatigue or negligence. The TMvision identification function can provide comprehensive improvement. The menu at the top of the TMvision setting interface can be used to add identify functions to the vision flow. The following describes the various functions in detail.

Module		Function	Output (floating point)
Barcode/QR code		Read the barcode, the 2D DataMatrix, or the QR code.	Content of the barcode or QR, for a successful read. “ ” (empty string) for a failed read.
Multi 1DBarcode		Identify multiple 1D barcodes in a region of interest	Content of the barcode for a successful read. “ ” (empty string) for a failed read.
OCR2		Detect textual data in an image. Enables higher character recognition accuracy than the OCR module.	String of an OCR result
Specific Color Area Size		Use the object's color area to determine whether the size of the area is within the decision range.	String. Output TMflow variation "OK" or "NG" according to conditions.
Color Classifier		Color classifier	Users set the characters for the string and for the training.

OCR	Detect textual data in an image	String of an OCR result
String Match	Compare strings	Matching results customized by users
External Classification	Use a remote computing platform with the protocol of HTTP to classify images.	String of an image classification result

Table 32: Function List – Identify

3.3.3.1 Barcode/QR Code

This function supports the decoding of 1-D barcode, QR code and 2-D DataMatrix. The user frames the barcode region in the **Set Barcode Range** for identification, choose a **Barcode Type**, or enable **Auto multi-angle rotation identification** to identify a 1-D barcode placed at any random angle. For barcodes in white symbols on black background: Users may select "Enhance" (and set Alpha value to -1) to invert the image before identifying it.

IMPORTANT

IMPORTANT:
Make sure there is only one clear barcode in the area for reading.

Barcode/QR code types supported:

1D Barcode Type	Minimum bar width (pixel)	Minimum bar height (pixel)
EAN-8	2	8
EAN-13	2	8
UPC-A	2	8
UPC-E	2	8
CODE 128	2	2
CODE 39	2	2
CODE 93	2	2
Interleaved 2 of 5	2	2

Table 33: Function List – Identify (Supported Barcodes)

2D Barcode Type	Minimum block size (pixel)	Modules	ECC Level
QR code	4 x 4	Model 2 (Version 1~40)	L, M, Q, H
Data Matrix	6 x 6	10 x 10 ~144 x 144	By data capacity*

*The maximum data capacity is 1023 characters.

Table 34: Function List – Identify (Supported QR codes)

Resolution	Object Distance (㎜)	Minimum print size (㎜) (N = Minimum pixel requiered)
5M	100	0.038*N
5M	200	0.076*N
5M	300	0.114*N
1.2M	100	0.077*N
1.2M	200	0.154*N
1.2M	300	0.231*N

Table 35: Minimum Print Size Requirements When Identifying a Barcode through TM Robot's EIH Camera

3.3.3.2 Multi 1D Barcode

This function supports the decoding of more than one 1-D barcode. The user selects the barcode region in the **Set Barcode Range** for the identification. For barcodes in white symbols on black background: Users may select "Enhance" (and set Alpha value to -1) to invert the image before identifying it.

IMPORTANT

IMPORTANT:
Make sure the barcodes in the selected region are clear for reading.

Barcode types supported:

1D Barcode Type	Minimum bar width (pixel)	Minimum bar height (pixel)
EAN-8	2	8
EAN-13	2	8
UPC-A	2	8
UPC-E	2	8
CODE 128	2	2
CODE 39	2	2
CODE 93	2	2
Interleaved 2 of 5	2	2

Table 36: Function List – Identify (Supported Barcodes)

NOTE:
- All the barcodes for identification must be of the same type.
- The values of the barcodes must be distinct from each other.
- The barcodes must be separated by at least 20 pixels.
- The value of an Interleaved 2 of 5 barcode must consist of no fewer than 6 bytes.
- Users can select an option from **Sorted by** to decide how the barcodes identified are arranged in the Barcode ID column below the Result image: **Left to Right**, **Right to Left**, **Top to Bottom**, **Bottom to Top**, **Nearest to Image Center**, **Nearest to Top-Left**, **Nearest to Top-Right**, **Nearest to Bottom-Left**, and **Nearest to Bottom-Right**.

3.3.3.3 OCR2

OCR2 enables higher character recognition accuracy than the OCR module.

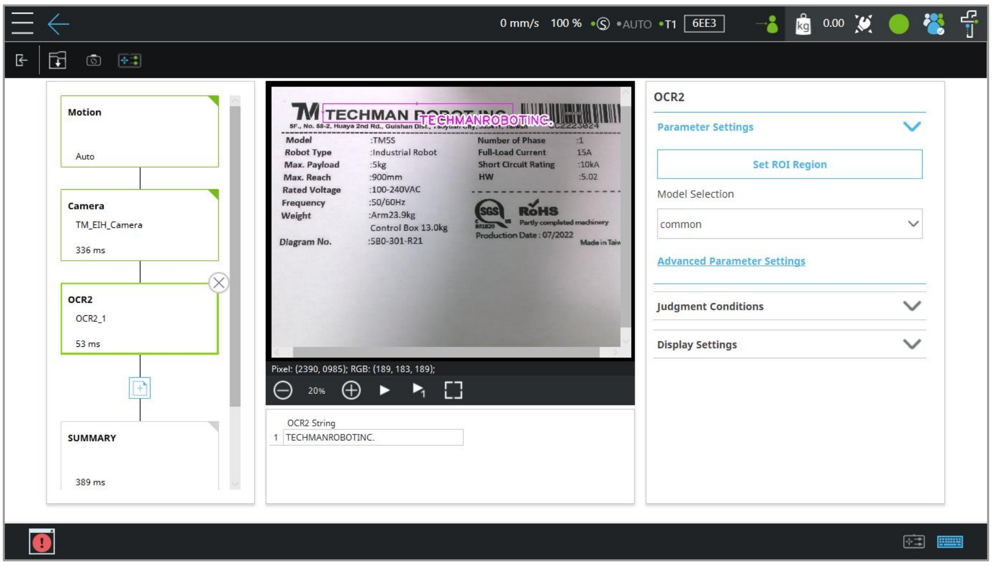


Figure 24: OCR2

➢ Support Content

- Outputs the identification results in strings.

- Supports 13 common fonts and their bold formats (Regular 400, **Bold 700**), as shown in the table below.

Font	Example
Arial, Consolas, OCR-B, and SimHei	Arial, Consolas, OcrB, SimHei
Lucida Bright	Lucida Bright
Times New Roman	Times New Roman
Verdana	Verdana
MS Gothic	MS Gothic
Courier New	Courier New
Fake Receipt	FAKE RECEIPT
Ticking Timebomb	0123456789
Seven Segment	0123456789
OCR-A	OCR-A Extended

Table 37: OCR2 Supported Fonts

- Supports 78 characters, including letters, digits, and punctuation marks.The identification area is a single line. Characters go from left to right in a straight line or a curve. A single line contains 32 characters at most.

➢ Parameter Setting Interface

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI Region	Set the location, size, and rotation of the range to search.
Model Selection	Choose the font to be identified.
Candidate of Words	Output according to the selected character list. Eliminate other similar characters.

Table 38: OCR2 Parameter Settings

➢ Set ROI Region

The region can be divided into rectangles or arcs. Drag the frame over the desired region to adjust the size of the region. Click the rotate symbol on the edge of the frame to rotate the region. The arrow on the edge of the frame represents the direction the characters are written. When using the arc region, single click the arrow to switch the direction of the arrow in correspondence to the concave or convex curved characters.

IMPORTANT:
The aspect ratio of a ROI must be lower than 12; the height of characters must be at least 50% higher than the height of a ROI.

- Model Selection

  Three trained types of characters are available for users to choose from:

  - Common: numerals (0 to 9), upper-case Latin alphabets (A to Z), and symbols (/ @ : ( ) - . # $ % & * + < = >).
  - Numeral: numerals (0 to 9) and symbols (- and .)
  - Universal: numerals (0 to 9), upper-and lower-case Latin alphabets (A to Z), and symbols (/ @ : ( ) - . # $ % & * + < = >).

- Candidate of Words

  Candidate characters can be set in the candidate character menu. Characters in black indicate candidate characters, and characters in gray indicate eliminated characters. The identification result does not output eliminated characters. Users can use @ (All), $ (Digit), # (Upper Case), * (Lower Case), or % (Symbol) to list and combine possible candidate character combinations. The first symbol in the combination represents the candidate character of the first character, the second symbol represents the candidate character of the second character, and so on.

3.3.3.4 Color Classifier

This function assists users in dealing with a color identification. Users are required to set up color classification area and select the color feature area for identification before clicking **Next** to initiate the training process. In addition, users are required to place patterns of different colors as prompted and name each color during the training process. Once trained successfully, the TMvision can classify color of the object to its most suitable category. Click **Parameter Adjustment** to set RGB and HSV parameters for each color in the list with the sliders, and click **OK** to update parameters or **Reset** to cancel. Users can also check **Uncertain Class** and set the **Threshold** for applications such as the assembly line with objects of unknown color to make the color classifier pick up the color of interest and leave other color as null. **Uncertain Class** works by matching the list of color with color classification area to get a matching score. If the score is below the threshold, it outputs **uncertain** in a string.

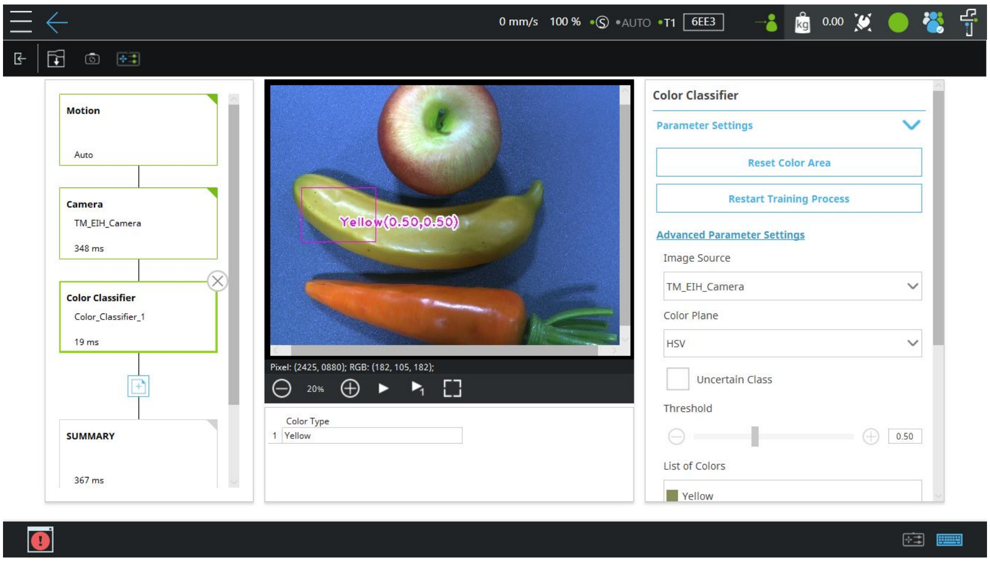


Figure 25: Color Classifier

3.3.3.5 OCR

This module detects textual data in an image.

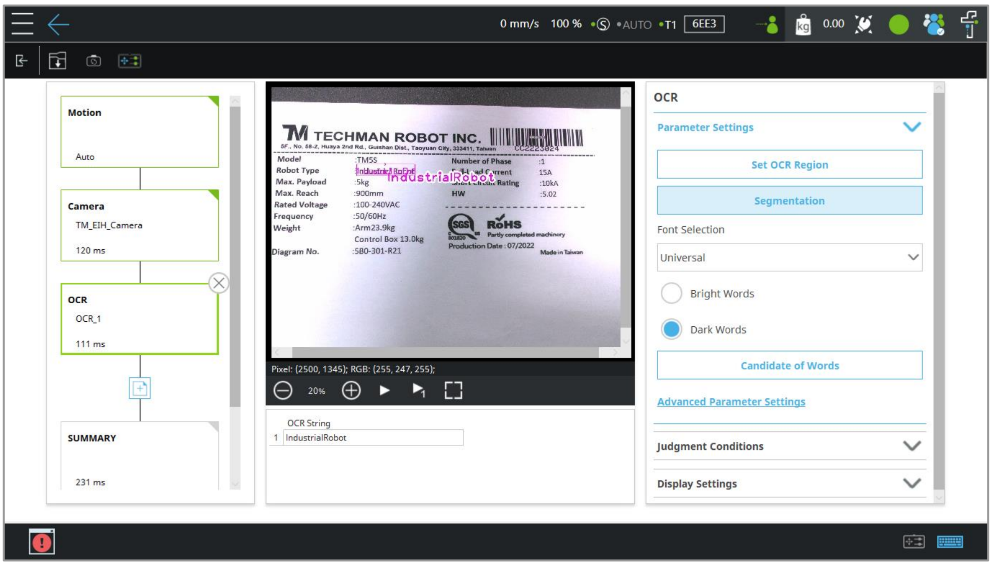


Figure 26: OCR

➢ Support Content

- Outputs the identification results in strings.
- Supports nine common fonts and their bold format (Regular 400, **Bold 700**) shown in the table below.

Font	Example
Lucida Bright, Times New Roman	Lucida Bright, Times New Roman
Arial, Verdana, MS Gothic	Arial, Verdana, MS Gothic
Courier New, Consolas, OC A Extended, OcrB	Courier New, Consolas, OCR A Extended, OcrB

Table 39: OCR Supported Fonts

- Supports 94 printable characters ranging from ASCII codes 21_{hex} to $7E_{hex}$ including letters, digits, punctuation marks, and a few miscellaneous symbols.
- The identification area is a single line. Characters go from left to right in a straight line or a curve. A single line contains 32 characters at most.

➢ Parameter Setting Interface

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set OCR Region	Set the location, size, and rotation of the range to search.
Segmentation	Adjust character segmentation parameters.
Font Selection	Choose the font to be identified.
Bright Words	White text and black background.
Dark Words	Black text and white background.
Candidate of Words	Output according to the selected character list. Eliminate other similar characters.

Table 40: OCR Parameter Settings

➢ Set OCR Region

The region can be divided into rectangles or arcs. Drag the frame over the desired region to adjust the size of the region. Click the rotate symbol on the edge of the frame to rotate the region. The arrow on the edge of the frame represents the direction the characters are written. When using the arc region, single click the arrow to switch the direction of the arrow in correspondence to the concave or convex curved characters.

➢ Segmentation

Name	Function
Bounding Rectangle Width (Pixel)	Character width must be within this range.
Set bounding rectangle height (Pixel)	Character height must be within this range.

Set minimum character spacing (Pixel)	Characters are combined when character spacing is lower than this value.
Set character fragment overlap (%)	Characters are combined when the character overlap ratio exceeds this value.
Set minimum character aspect ratio (%)	Character height divided by width. Characters are segmented if it is lower than this value.
Set skew correction (Degree)	Angle correction. Turn tilted characters upright.
Ignore Border Characters	Exclude the characters cropped by the ROI borders to generate more accurate segmentation results.

Table 41: OCR Parameter Settings – Segmentation

- Font Selection

  Four trained types of characters are available for users to choose from: Universal (94 characters), Universal_Digit (numeral 0 to 9), Universal_UpperCase (Latin alphabet (A to Z)), Universal_LoweCase (Latin alphabet (a to z))

- Candidate of Words

  Candidate characters can be set in the candidate character menu. Characters in black indicate candidate characters, and characters in gray indicate eliminated characters. The identification result does not output eliminated characters. Users can use @ (Universal), $ (Digit), # (Upper Case), * (Lower Case), or % (Symbol) to list and combine possible candidate character combinations. The first symbol in the combination represents the candidate character of the first character, the second symbol represents the candidate character of the second character, and so on.

3.3.3.6 String Match

This function compares strings from sources in the flow or with a fixed string set by users, and generates the matching customizable results for further applications. In String 1, users can select the source in the **Connected to** dropdown, or check **Fixed String** and fill a desired string in the field below. Repeat the same process for String 2. Finally, customize the messages with color to output as the results for Match or Mismatch.

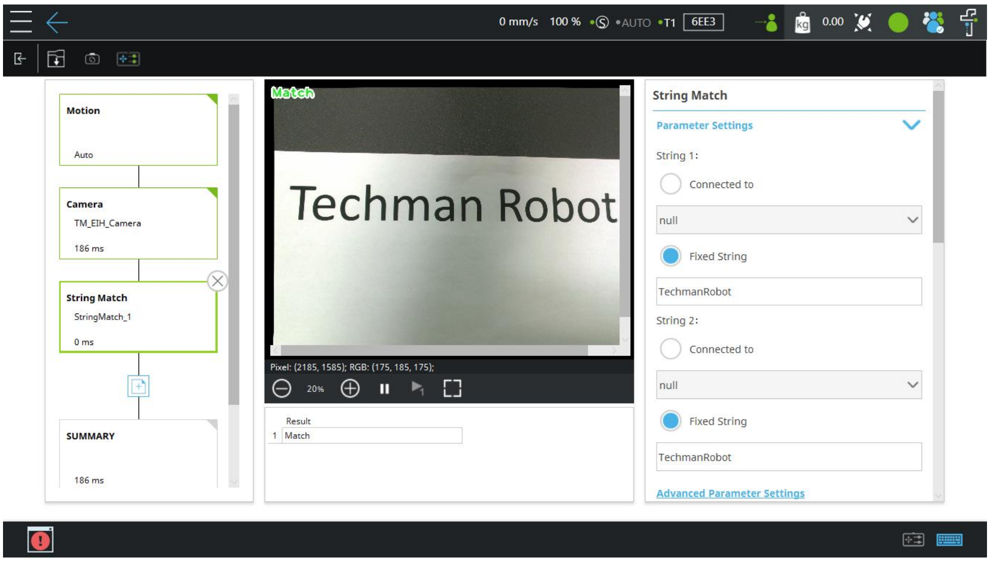


Figure 27: String Match

3.3.3.7 External Classification

External Classification uses a remote computing platform with the protocol of HTTP to classify images.

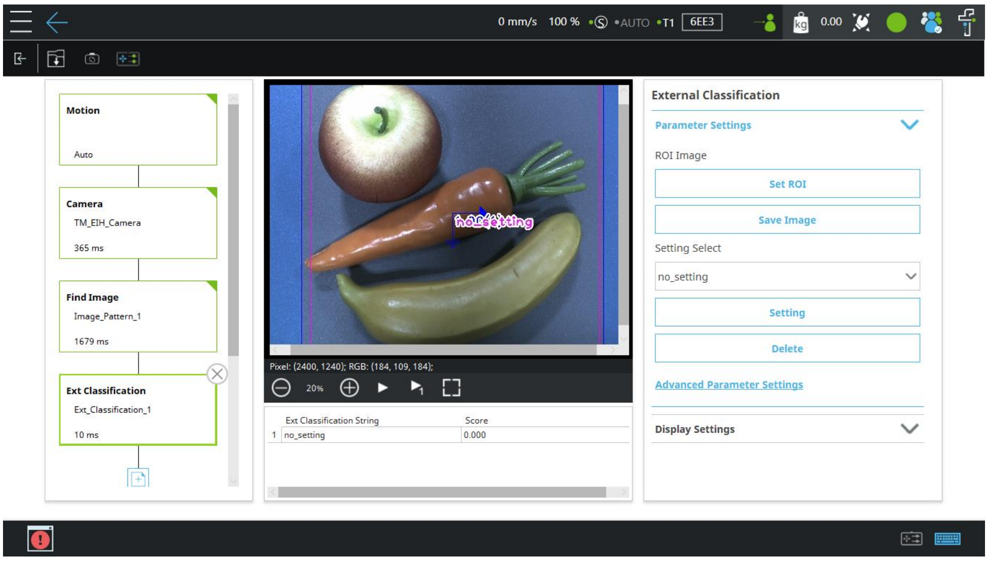


Figure 28: External Classification (1/2)

Use the dropdown box below **Image Source** to select the source of the image. In the **Name** field, input the name for the classification. Use **Set ROI** button to set regions of searching, rotation, and scaling positions. Use the dropdown box below **Setting Select** to select configured HTTP parameters. The default goes without any selected model and outputs no_model string while the project is running. Use **Setting** button to modify parameters for the respective model. Parameters in **HTTP Setting** and **Inference POST** are **Get**, **URL**, **Post Key**, **Value**, **jpg/png**, **Timeout (ms), Setting**

Name. A warning message prompts if **HTTP Setting** is overwritten with the same **Setting name**. No identical individual **Setting Name of HTTP Setting** is allowed in one TM Robot.

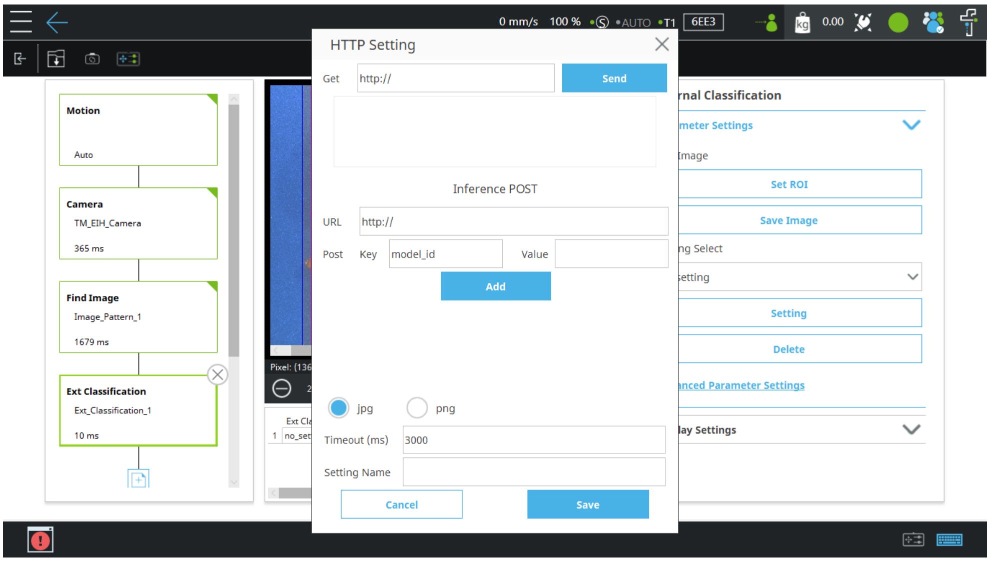


Figure 29: External Classification (2/2)

NOTE:

As a network communication protocol, HTTP works only when the connection is established. External Classification uses POST cmd on every classification to send pictures to the HTTP server by the configured URL. The HTTP server inspects the pictures by breaking up the relevant key-values and returns the result in the JSON format packets to TM Robot.

Protocol Define of Identify – External Classification

1. Image size : arbitrary
2. Image format : jpg or png
3. Our Classification module will output the 'result' value if the 'message' value is "success", or the error message otherwise.
4. Give score between 0.000 and 1.000

Example

1. image: Image.jpg
2. curl example:

curl -X POST "http://127.0.0.1:4585/api/CLS" –F image=@"c:/Image.jpg" -F "model_id=test"

3. JSON response

```
{
    "message": "success",
    "result": "NG",
    "score": 0.987
}
```

Drag the slider below **Score Threshold** to set a threshold for classification. Use **Save Current Image** button to save the inspected region of the image. When the system cannot find any path set for saving the image, it saves the image to a root directory of a USB drive labeled “TMROBOT.” The image is saved as yyyy-MM-dd-HH-mm-ss_zzz.jpg in the path [drive_letter]:\project_name\job_name\yyyy-MM-dd\object_name\.

When the vision job of TMflow comes to an end, the module External Classification outputs the result of the image classification in a string with a length limit of 1024 characters.

3.3.4 Measure

The object measurement module is TMvision software module. Click the Add button at the top of the TMvision setting interface to add the measurement function to the vision Flow. TMvision measurement module can be used to calculate the object's quantity and the image's geometric position and angle, as well as make measurements. The measurement results are outputted as variations. The user can match the TMflow logic node according to the variations to check whether the measurement results conform to regulations. The user can pre-set the flow according to the results. The following describes this functions in detail.

Module	Output
Gauge	Value, object quantity. When measurement cannot be done, the output TMflow variation is -1.
Calipers	Value in integer, pitch quantity. Array in floating point, width of each pitch. When measurement cannot be done, the pitch Is 0.
Counting (Edges)	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Specific Color Area Size	Value in integer, color area
Number OCR	Value, result of number character recognition. When the characters cannot be found, the output of TMflow variable is 0.
Additional Module	**Output**
Counting (Shape)	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Counting (Image)	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Counting (Blobs)	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Pose Variation(Shape)	Float point. Use the object's shape feature to calculate the variation of X, Y and the askewness of R . When the object cannot be found, the output of TMflow variation is 0.
Pose Variation(Image)	Float point. Use the object's image feature to calculate the offset of X, Y and the askewness of R . When the object cannot be found, the output of TMflow variation is 0.
Subtract Reference Image	Value in integer. Use the difference between the source image and the reference image to calculate the number of defects. Integer array, area size of each defect

Line Burr		Int value. Use the differences between the detected edge and the ideal straight line distance to calculate the total defect area. When the object cannot be found, the output of TMflow variation is 0.
Circle Burr		Int value. Use the differences between the detected edge and the ideal circular radial distance to calculate the total defect area. When the object cannot be found, the output of TMflow variation is 0.

Table 42: Measuring Functions

3.3.4.1 Gauge

This module can add new anchors, straight lines, round shapes, objects (shape), or objects (image) as measuring elements. Choose two elements to measure pixel distance or angle. The measurement result is displayed as red lines and characters.

Name	Function
Name	Name the task.
Add New Gauge Element	Add new measurement elements from the list.
Add New Measure	Choose two elements from the list to measure the distance or angle.
Unit of Distance	The pixels can be converted to millimeters by the calibration plate or OMRON Landmark (for reference only).

Table 43: Gauge Functions

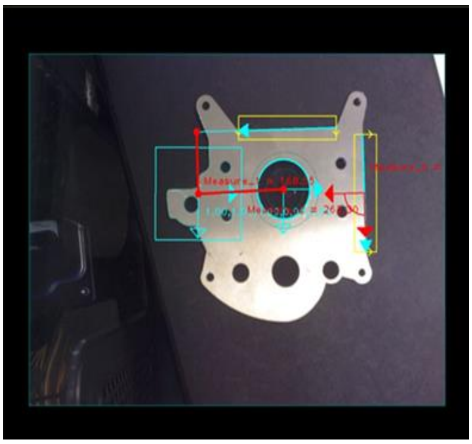


Figure 30: Gauge Example

3.3.4.1.1 Anchor

Choose a point in the image as the anchor to measure the distance and the angle between the anchor and any other element. Use the slider to adjust the anchor point placement and angle.

Name	Function
Image source	Choose image source.
Name	Name the task.
Manual Adjustment	Manually drag the anchor point to the target position.
Shift in X	Move the anchor in the X direction.
Shit in Y	Move the anchor in the Y direction.
Rotation	Rotate the anchor around the initial point.

Table 44: Anchor Functions

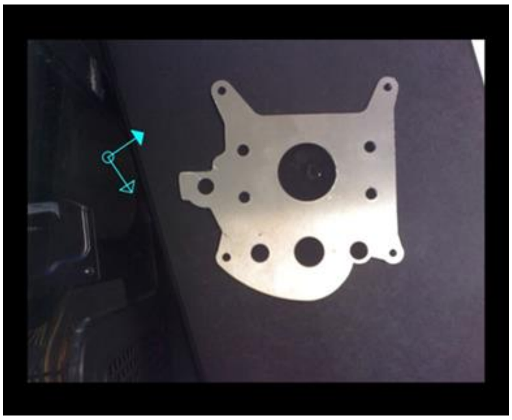


Figure 31: Anchor Example

3.3.4.1.2 Line

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI	Select the object edge of the newly added straight line in the pop-up window. The direction that the mouse is dragged determines the direction of the straight line.
Scan Direction	Brightness change direction of the detection edge. After selecting the ROI, the frame will show the detection direction.
Intensity Threshold	Only threshold difference greater than this value will be detected.

Table 45: Line Functions

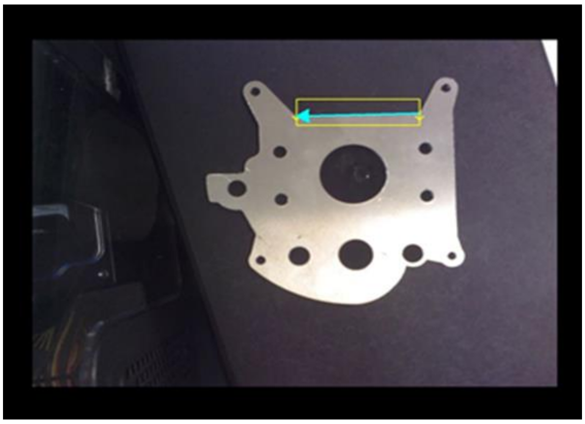
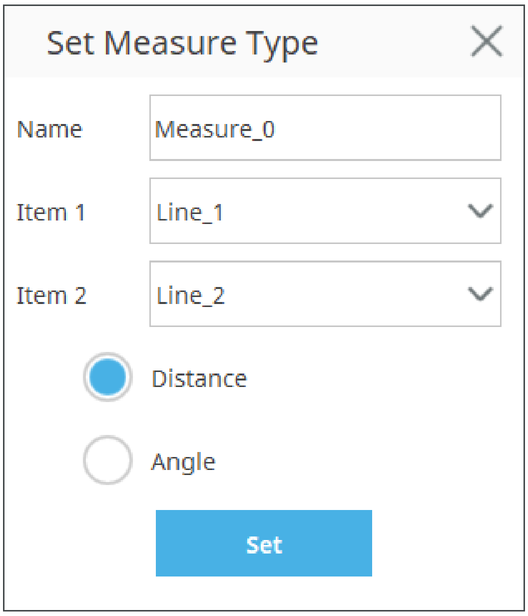


Figure 32: Line Example (1/2)

Users can measure the distance between lines as shown below.



The measured distance goes from the center of **Item1** at left to the nearest edge of **Item2** at right

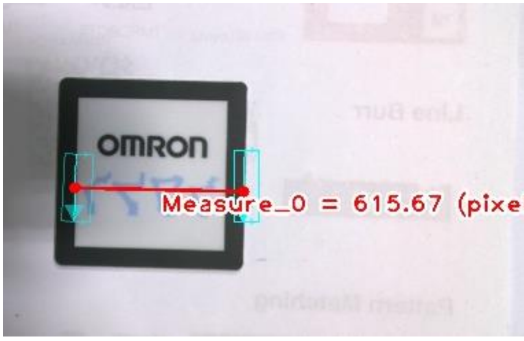


Figure 33: Line Example (2/2)

3.3.4.1.3 Circle

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI	Select the newly added round shape in the pop-up window. The ROI shows two rounds with the same center. The shape is adjusted to be between the two rounds with the same center. The image strength threshold and the measurement angle are adjusted to stabilize the result.
Intensity Threshold	Only objects whose edge gradient grayscale difference exceeds this threshold will be detected.

Table 46: Circle Functions

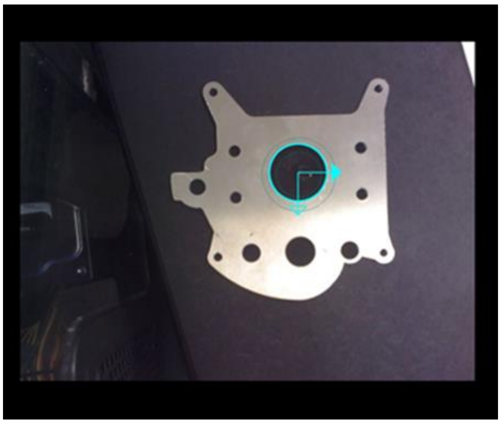


Figure 34: Circle Example (External)

3.3.4.1.4 Shape-based Pattern

Click **Select Pattern** to select the shape of the newly added object in the pop-up window. Use **Edit Pattern** to change the object shape and **Set Search Range** to set the pattern’s range in the image. Adjust the **Number of Pyramid Layers** and the **Minimum Score** to stabilize the result. Check **Directional Edge** to let the directions of the pattern's edges influence the identification results.

3.3.4.1.5 Image-based Pattern

Click **Select Pattern** to select the image of the newly added object in the pop-up window. Use **Set Search Range** to set the pattern’s range in the image. Adjust the **Number of Pyramid Layers** and the **Minimum Score** to stabilize the result. To find an appropriate measuring method, choose **Absolute Difference** or **Correlation Coefficient** from the dropdown box below Similarity Metric.

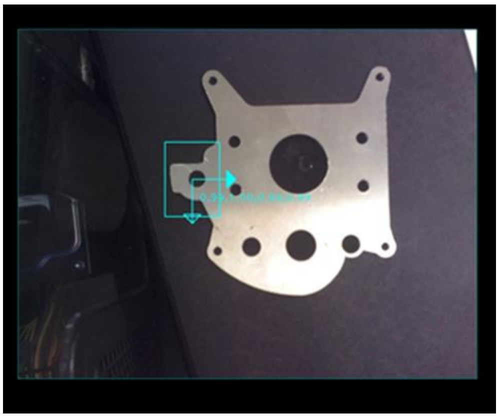


Figure 35: Image-based Pattern Example

3.3.4.2 Calipers

This module measures the pitch formed by multiple edges (Edge Pitch) or the maximum width (Peak-to-Peak Width) in the detection region.

Name	Function
Image Source	Choose an image source.
Name	Name the task.
Select ROI	After clicking, a window will pop up. Users can select the region and the direction to measure on the image.
Method	Peak-to-Peak Width.

Table 47: Caliper Functions

3.3.4.2.1 Peak-to-Peak Width

Measure the outermost edge of the detection line in the region and calculate the maximum width by on the outermost edge of each detection line.

Name	Function
Intensity Threshold	Adjust the value as the threshold for the edge intensity. Only a value higher than the threshold counts as an edge.
Measurement density	Adjust the amount of the density lines in the region to measure.
Unit of Distance	The pixels can be converted to millimeters by the calibration plate or OMRON Landmark (for reference only).

Table 48: Peak-to-Peak Width Functions

Figure 36: Caliper (Peak-to-Peak Width) Example

3.3.4.3 Counting (Edges)

Use the detection of part edges to calculate the number of parts.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Scan Direction	Detect the edge's brightness change direction. After choosing the ROI, the frame will show the detection direction.
Intensity Threshold	Only threshold differences greater than this value will be detected.
Search Width (Pixel)	The spacing distance of the search edge.
Search Angle	The searchable edge angle.

Table 49: Counting (Edges) Functions

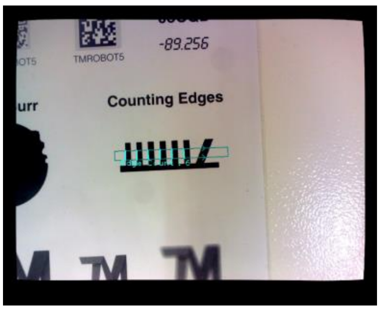
		
Dark to light	**Light to dark**	**Dual direction**

Table 50: Counting (Edges) Examples

Note

NOTE:
Based on the camera resolution, the theoretical maximum number of vertical edges that can be detected is 1296.

3.3.4.4 Specific Color Area Size

This function calculates an object's color area.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Add Ignorance Area	Click to set the region to be omitted. The area within the range will not be added to the decision.
Color plane	Choose RGB or HSV as the color space.
Extract Color	After clicking, this image window will appear. The user can select the color region to be detected on the image.
Red/Hue	Adjust the color feature's red/hue value to be detected.
Green/Value	Adjust the color feature's green/value to be detected.
Blue/Saturation	Adjust the color feature's blue/saturation value to be detected.

Table 51: Specific Color Area Functions

This example detects whether the liquid capacity in the container reaches the standard.

OK	NG
	

Table 52: Specific Color Area Size Example

3.3.4.5 Number OCR

This module detects numbers in an image

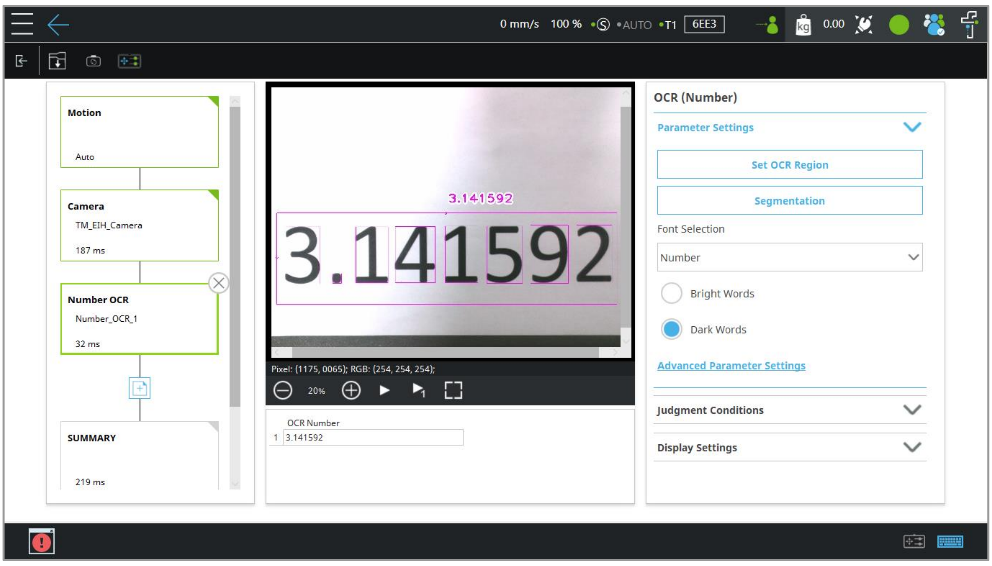


Figure 37: Number OCR

➢ Support Content

- Number OCR function can output identification result in floating-point numbers.

Font	Type
serif	Lucida Bright, Times New Roman
sans-serif	Arial, Verdana, MS Gothic
monospaced	Courier New, Consolas, OCR A Extended, OcrB

Table 53: Number OCR Supported Fonts

- Supports Seven-segment-display.
- Supports 12 characters, including numbers (**0**~**9**), **-** , and **.** to determine positive, negative, the numbers, and the decimal point.
- Identification region is a single line. Characters go from left to right in a straight line or a curve. The output numeral range is valid for 7 digits as the single-precision floating-point format.

➢ Parameter Setting Interface

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set OCR Region	Set the location, size, and rotation of the range to search.
Segmentation	Adjust character segmentation parameters.
Font Selection	Choose the font of the region to be identified.
Bright Words	White text and black background.
Dark Words	Black text and white background.

Table 54: Number OCR Parameter Settings

- Setting Identification Region

  The identification region can be divided into rectangles or curves. Drag the frame over the desired region to adjust the size of the identification region. Click the rotate symbol on the edge of the frame to rotate the identification region. The arrow on the edge of the frame represents the direction the characters are written. When using the curved region, single click the arrow to switch the direction of the arrow in correspondence to the concave or convex curved characters.

- Segmentation

Name	Function
Bounding Rectangle Width (Pixel)	Character width must be within this range.
Set bounding Rectangle height (Pixel)	Character height must be within this range.
Set minimum character spacing (Pixel)	Characters are overlapped when character spacing is lower than this value.
Set character fragment overlap (%)	Characters are combined when the character overlap ratio exceeds this value.
Set minimum character aspect ratio (%)	Character height divided by width. Characters are segmented their ratio is lower than this value.
Set skew Correction (Degree)	Angle correction. Turn tilted characters upright.
Ignore Border Characters	Exclude the characters cropped by the ROI borders to generate more accurate segmentation results.

Table 55: OCR Parameter Settings – Segmentation

- Font Selection

  The Number OCR provides two font models for the user to choose from, Number and seven-segment-display. While Number font includes the OCR fonts and seven-segment display font model, seven-segment-display font adopts font Digital Counter 7 and font Ticking Timebomb BB for reading only.

3.3.4.6 Counting (Shape)

Name	Function
Image Source	Choose image source.
Name	Name the task.
Select Pattern	After clicking, this image window will pop up. The user can select items from the image.
Edit Pattern	Click and the edit window pops up to edit shape feature of the object.
Set Search Range	Set the location, size, and rotation of the range to search.

Name	Function
Number of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Minimum Score	Object can be identified only when the score of the detection result is higher than the minimum setting.
Directional Edge	Select whether the shape edge is directional.

Table 56: Counting (Shape) Functions

The following example uses the shape feature to detect product quantity (This example first uses the Morphology function to capture the shape of the object in the image. This improves object detection regardless of differences in objects).

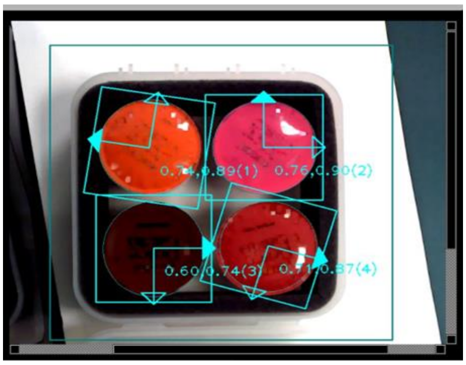
	
Pattern Selection	Identifiable object

Table 57: Counting (Shape) Example

3.3.4.7 Counting (Image)

Name	Function
Image Source	Choose image source.
Name	Name the task.
Select Pattern	After clicking, this image window will pop up. The user can select items from the image.
Set Search Range	Set the location, size, and rotation of the range to search.
Number of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Minimu Score	Object can be identified only when the score of the detection result is higher than the minimum setting.
Similarity Metric	Users can pick "Correlation Coefficient" or "Absolute Difference" as the most appropriate measuring method. The former has a slower speed, but is tolerant of ambient light differences, and the light and shadow changing ability is stronger.

Table 58: Counting (Image) Functions

The following example uses the image feature to detect the correct number of printings.

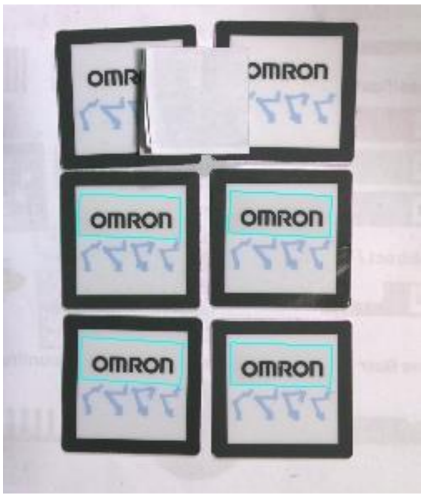


Figure 38: Counting (Image) Example

3.3.4.8 Counting (Blobs)

This module uses the object's color and area feature to calculate the number of irregular objects in the image.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set Search Range	After clicking, this window will pop up. The user can select the region to be detected on the image.
Color Plane	Choose RGB or HSV as the color space.
Extract Color	After clicking, this image window will appear. The user can select the color region to be detected on the image.
Red/Hue	Adjust the color feature's red/hue value to be detected.
Blue/Saturation	Adjust the color feature's blue/saturation value to be detected.
Green/Value	Adjust the color feature's green/value to be detected.
Area Size	Only color area in this value range will be included in the quantity.

Table 59: Counting (Blobs) Functions

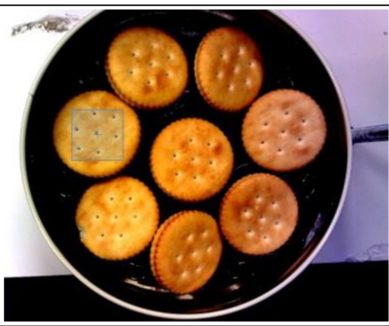
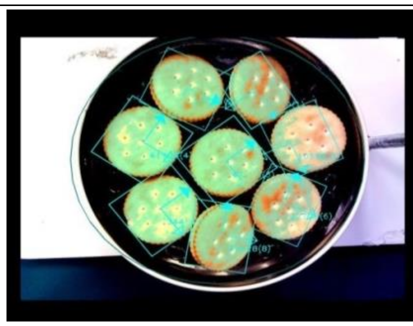
	
Pattern Selection	**Identifiable object**

Table 60: Counting (Blobs) Example

3.3.4.9 Pose Variation (Shape)

This module uses the object's shape feature to calculate variation and askewness. This can be used to inspect whether the label position on the product has changed or is askew.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Select Pattern	After clicking, this image window will pop up. The user can select items from the image.
Edit Pattern	Click and the edit window pops up to edit shape features of the object.
Set Search Range	Set the location, size, and rotation of the range to search.
Number of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Minimum Score	Object can be identified only when the score of the detection result is higher than the minimum setting.
Directional Edge	Select whether the shape edge is directional.

Table 61: Pose Variation (Shape) Functions

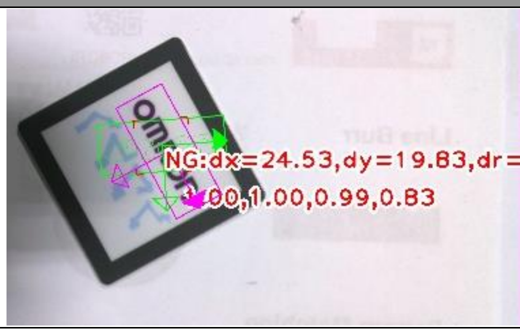
OK	NG
	

Table 62: Pose Variation (Shape) Examples

3.3.4.10 Pose Variation (Image)

This module uses the object's image feature to calculate variation and askewness.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Select Pattern	After clicking, this image window will pop up. The user can select items from the image.
Edit Pattern	Click and the edit window pops up to edit shape features of the object.
Set Search Range	Set the location, size, and rotation of the range to search.

Name	Function
Number of Pyramid Layers	The number of processing iterations to perform on the image. More layers reduces processing time, but for images with a lot of detail, the detail may get lost, resulting in detection errors.
Minimum Score	Object can be identified only when the score of the detection result is higher than the minimum setting.
Similarity Metric	The user can choose the "Correlation Coefficient" or the "Absolute Difference" to as the most appropriate measuring method. The former is slower, but it can resist environmental lighting and has stronger light and shadow change capability.

Table 63: Pose Variation (Image) Functions

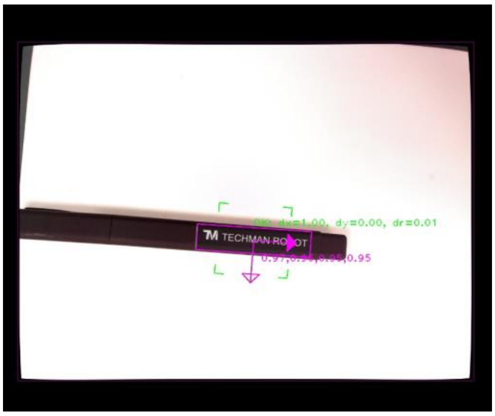
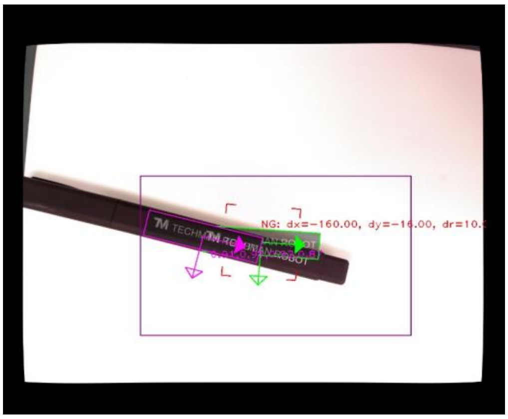
OK	NG
	

Table 64: Pose Variation (Image) Example

3.3.4.11 Subtract Reference Image

This module uses the difference between the source image and the reference image to calculate the number of defects and their sizes.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Select Reference Image	After clicking, this image window will pop up. The user can choose the reference image on this image.
Add Ignorance Area	Clicking can set the region to be omitted. Defects within the range will not be included in the decision.
Intensity Threshold	Only differences with the reference image's gray value larger than this value will be included in the defect area.
Defect Size	Only defect areas in this range will be included in the defect quantity.
Bounding Box	Select this function to show the defect position with a bounding box.
Local Alignment	Enhance stability of recognition in case the object is too small to detect by correcting the position and the angular deviation. The compensate range of the position and the angle are ±5 pixels and ±5°, respectively.
Deburring	Remove the image edge or erroneous determination caused by pattern matching.
Element Size	Remove the burr calculation element size.

Table 65: Subtract Reference Image Functions

This example shows the detection of whether the product printing has defects.

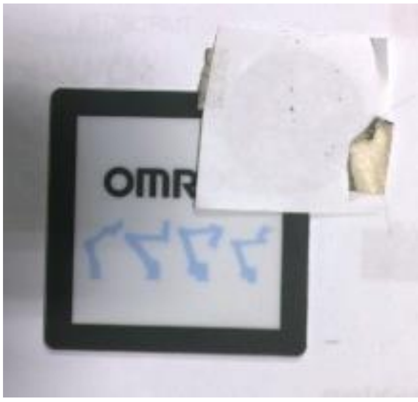
Reference image	Defect image	Detection result image
		

Table 66: Subtract Reference Image Example

IMPORTANT:
When the "Find" module caused a position error, the burr on the edge will be erroneously determined as damage. The user can select the deburring function. The larger the element size the greater the calculation range.

3.3.4.12 Line Burr

This module uses the differences between the detected edge and the ideal straight line distance to calculate the total defect area.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Scan Direction	Detect the edge's brightness change direction. After choosing the ROI, the frame will show the detection direction.
Intensity Threshold	Only gray value threshold differences larger than this value will be detected.
Distance (Pixel)	Only differences with the ideal straight line distance larger than this value will be included in the defect area.

Table 67: Line Burr Functions

This example detects whether the part's edge has burrs or defects.

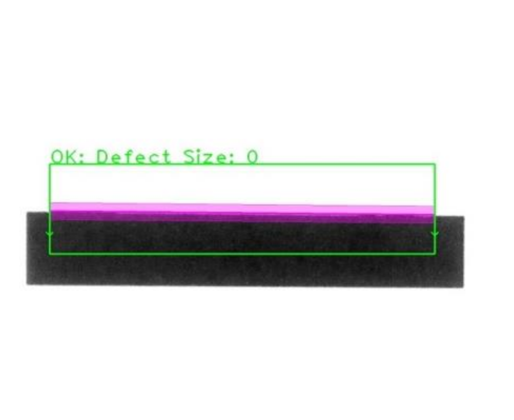
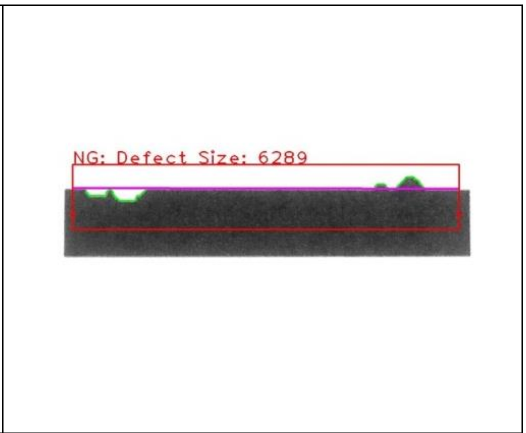
	
OK	**NG**

Table 68: Line Burr Example

3.3.4.13 Circle Burr

This module uses the differences between the detected edge and the ideal circular radial distance to calculate the total defect area.

Name	Function
Image Source	Choose image source.
Name	Name the task.
Set ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Intensity Threshold	Only threshold differences greater than this value will be detected.
Angle	The spacing angle of the detected edge points.
Distance (Pixel)	Only differences with the ideal circular radial distance greater than this value will be included in the defect area.

Table 69: Circle Burr Functions

This example is detecting whether the edge of the detected round object has burrs or defects.

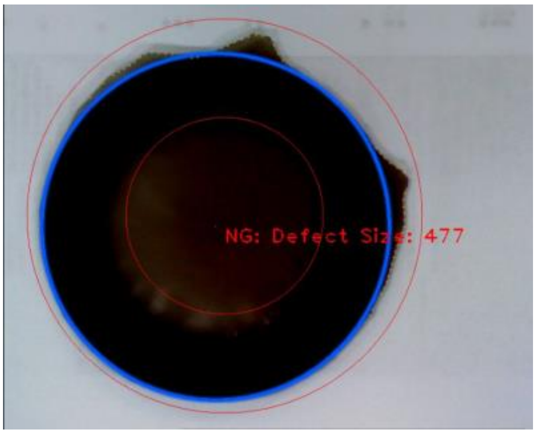


Figure 39: Circle Burr Example

3.4 I/O Parameter Setting

In the **Save Job** page, the input and output parameters of a vision task can be added on the **I/O Parameter Setting** list. Users can filter parameters by input/output or module and they can also customize parameter names.

The parameters can be used in TMflow with **SET Node**, and the settings of the vision task can be modified through the parameters when the project is running.

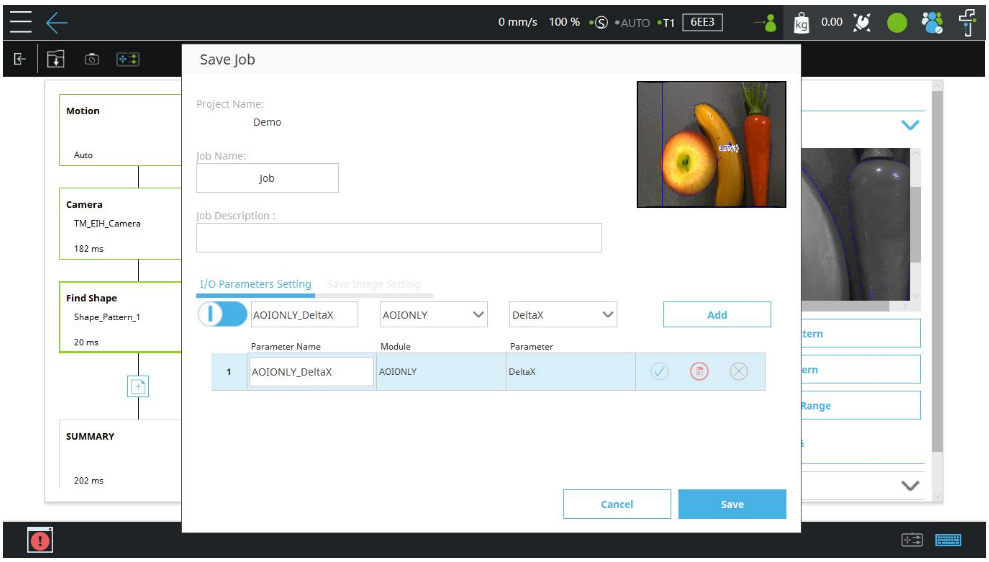


Figure 40: I/O Parameter Setting

4. TM External Camera

4.1 Overview

TM external camera supports connections for up to two external cameras at the same time. TMvision also provides provides a support tool to help users adjust the external camera's various parameters. External cameras can be used for all TMvision tasks except servoing. There is also an alignment compensation function that is divided into the eye-to-hand or upward-looking camera according to application. The following introduces various camera types and related settings.

4.2 Types of Camera Supported

Brand	Type	Specification
BASLER	acA2500-14gc/gm	GigE (14 fps at 5 MP) Rolling Shutter
	acA 2500-20gc/gm	GigE (14 fps at 5 MP) Global Shutter
	acA 2440-20gc/gm	GigE (23 fps at 5 MP) Global Shutter
	acA 3800-10gc/gm	GigE (10 fps at 10 MP) Rolling Shutter
	acA 4024-8gc/gm	GigE (8 fps at 12.2 MP) Rolling Shutter
	ace 2 Series	GigE/USB (5 / 9.1 / 12.3 / 20.2 MP) Rolling/Global Shutter
Flir	BFLY-PGE-50A2C-CS(color)	GigE (13fps at 5 MP) Rolling Shutter
	BFLY-PGE-50A2M (Gray)	GigE (13fps at 5 MP) Rolling Shutter
	BFLY-PGE-50S5C-C (Color)	GigE (22fps at 5MP) Global Shutter
	BFLY-PGE-50S5M-C (Gray)	GigE (22fps at 5MP) Global Shutter
	BFS-PGE-50S5C-C (Color)	GigE (24fps at 5MP) Global Shutter
	BFS-PGE-120S4C-CS (Color)	GigE (8.5fps at 12MP) Rolling Shutter
	BFS-PGE-120S4M-CS (Gray)	GigE (8.5fps at 12MP) Rolling Shutter
	BFLY-PGE-09S2C-CS (Color)	GigE (30fps at 0.9MP) Global Shutter
	BFS-PGE-200S6M-C (Gray)	GigE (6.1fps at 20MP) Rolling Shutter

Table 70: Types of Camera Supported

4.3 External Camera Installation Procedure

Step 1:	Enter TM Flow -> System setting -> Network setting.
Step 2:	Select "Static IP" and enter the following settings. Click Confirm. Set IP address: use either 192.168.61.101 or 192.168.88.102 subnet mask: 255.255.255.0
Step 3:	Enter the Setting page -> Visual setting -> left side "Camera list" on a blank spot, click the right mouse button -> select "Detect GigE Camera".
Step 4:	Wait for the camera detection to refresh -> left side "Camera list" on a blank spot, click the right mouse button -> select "Refresh Camera List".
Step 5:	GigE camera complete and the camera appears on the camera list. The camera will show "Unknown" at this time.
Step 6:	Once the user completes the steps in the implementation section 4.4 Calibrating the External Camera, the external camera function will be activated.

IMPORTANT

IMPORTANT:
Ensure the camera is connected to the control box's network outlet and the signal light is on.

4.4 Calibrating the External Camera

Once the external camera has been connected, the user needs to calibrate the camera and choose between the eye-to-hand or upward-looking mode for the camera. This establishes the corresponding position between the external camera and the eye-in-hand camera, as well as calibrates the camera's internal parameters.

4.4.1 ETH Camera Calibration

4.4.1.1 Automatic

Before calibrating a workspace, calibrate the intrinsic parameters of the ETH camera.

- Calibrating the intrinsic parameters of the ETH camera: Place the calibration plate within the camera’s field of view. Click **Capture** and repeat the same step 15 times (with the calibration plate placed at different positions and angles each time). After that, click **Next**.

Note

NOTE:

1. If the camera’s intrinsic parameters have been calibrated, a dialog box will pop up asking whether to load the parameters. To skip this step, click **Yes**.
2. If the external camera’s aperture and focus has been adjusted, its

intrinsic parameters should be re-calibrated.

After the intrinsic parameters is calibrated, calibrate the workspace. To do so, complete a simple hardware setup and set relevant parameters as needed.

- Hardware setup

1. Place the calibration plate: The plate must be placed in the workspace and within the field of view of the ETH camera. Make sure the plate can be detected.
2. Adjust the image-capture position: Move the robot to its initial position. The camera should be placed 10 to 30 cm above the calibration plate to make sure the plate is detected.

IMPORTANT

IMPORTANT:
Once calibration begins, the robot will move above the calibration plate. So, keep adequate clearance for the robot during calibration.

After the hardware setup is completed, workspace calibration will begin automatically. Once the calibration procedure is finished, users can check the calibration accuracy and save this result as a workspace file. The workspace file can be used in fixed-point vision jobs.

IMPORTANT

IMPORTANT:
Keep adequate clearance for the robot, as it moves around its initial position during automatic calibration.

4.4.1.2 Manual

Manual calibration involves five steps: **Camera Calibration**, **Set Workspace**, **Select Tool**, **Workspace Calibration**, and **Save Result**.

Note

NOTE:
Before starting calibration: Mount the required calibration tool on the robot tool flange. Techman Robot recommends using the calibration pin set provided by Techman Robot as the calibration tool. Use TMflow (TCP Setting) to set the Z height of the calibration tool. This tool must be calibrated through the TCP to obtain the coordinates of its installation.

IMPORTANT:
Do not move the calibration plate before calibration is finished.

Step 1 **Camera Calibration**:

Calibrate the camera's intrinsic parameters. Move the calibration plate to the camera's field of view and click **Capture**. Repeat this step 15 times (with the calibration plate placed at different positions and angles). After that, click **Next**.

Step 2 **Set Workspace**:

Complete a simple hardware setup and set relevant parameters as needed.

- Hardware setup

  Place the calibration plate: The plate must be placed in the workspace and within the ETH camera's field of view. Make sure the plate can be detected.

Step 3 **Select Tool**:

Select the TCP of the current calibration tool.

Step 4 **Workspace Calibration**:

This means calibrating the relation between the ETH camera and robot. Point the TCP to each red circle appearing on the calibration plate; repeat this step and click **Record** to complete the calibration.

Step 5 **Save result:**

Confirm the calibration result and save this result as a workspace file. The workspace can be used in fixed-point vision jobs.

4.4.2 Upward-Looking Camera Calibration

4.4.2.1 Automatic

Users must complete a simple hardware setup and set relevant parameters as needed.

- Hardware setup

1. **Place Calibration Plate:** The plate should be attached to the robot's end effector.
2. **Adjust Robot Capture Position**: Move the robot above the upward-looking camera and align the calibration plate with the center of the image captured while maintaining a distance of 10–30 cm between the plate and the camera and making sure the plate is detected. Maintain a movable range of 20 cm for the robot's end tool.

- Parameter settings
  1. **Camera Intrinsic Calibration**: Automatic upward-looking workspace calibration involves calibrating camera's intrinsic parameters. If the parameters have been calibrated, you can skip this step and do tilt correction.
  2. **Skip Tilt Correction**: Automatic workspace calibration includes tilt correction. If you want to maintain the robot's initial position and posture, skip this step.

Note

NOTE:
Skip correction involves changing the robot's initial position and posture to make sure the camera is level with the calibration plate. Users are best advised to perform tilt correction be performed; without it, calibration accuracy may decline.

  3. **Calibration Plate Thickness Compensation**: The calibration plate has some thickness of its own, and its thickness can be compensated for by setting this parameter (1.8 mm by default) to have the calibration distance aligned with the actual operation surface.

Note

NOTE:
Since the calibration distance does not change, the robot will lower its initial image-capture position to align with the distance if Calibration Plate Thickness Compensation is set.

After completing the hardware setup and setting the parameters, start the calibration procedure. After the procedure is over, confirm the calibration accuracy and save this result as a workspace file. The workspace file can be used in fixed-point vision jobs.

IMPORTANT

IMPORTANT:
Keep adequate clearance for the robot, as it moves around its initial position during automatic calibration.

4.4.2.2 Manual

Manual calibration involves five steps: **Camera Calibration**, **Select Tool**, **Set Workspace**, **Workspace Calibration**, and **Save Result**.

NOTE:

Before starting calibration: Mount the required calibration tool on the robot tool flange. Techman Robot recommends using the calibration pin set provided by Techman Robot as the calibration tool. Use TMflow (TCP Setting) to set the Z height of the calibration tool. This tool must be calibrated through the TCP to obtain the coordinates of its installation.

IMPORTANT:

Do not move the calibration plate before calibration is finished.

Step 1 **Camera Calibration**:

Calibrate the camera's intrinsic parameters. Move the calibration plate to the camera's field of view and click **Capture**. Repeat this step 15 times (with the calibration plate placed at different positions and angles). After that, click **Next**.

Step 2 **Select Tool**:

Select the TCP of the current calibration tool.

- Parameter settings

  Calibration Plate Thickness Compensation: The calibration plate has some thickness of its own, and its thickness can be compensated for by setting this parameter (1.8 mm by default) to have the calibration distance aligned with the actual operation surface.

IMPORTANT:

Since the calibration distance does not change, the robot will lower its initial image-capture position to align with the distance if Calibration Plate Thickness Compensation is set.

Step 3 **Set Workspace**:

Complete a simple hardware setup and set relevant parameters as needed.

- Hardware setup
  1. Place Calibration Plate: The plate should be attached to the robot's end effector.
  2. Adjust Robot Capture Position: Move the robot above the upward-looking camera and align the calibration plate with the center of the image captured while maintaining a distance of 10–30 cm between the plate and the camera and making sure the plate is detected. Maintain a movable range of 20 cm for

the robot's end tool.

- Parameter settings

  Calibration Plate Thickness Compensation: The calibration plate has some thickness of its own, and its thickness can be compensated for by setting this parameter (1.8 mm by default) to have the calibration distance aligned with the actual operation surface.

NOTE:
Since the calibration distance does not change, the robot will lower its initial image-capture position to align with the distance if Calibration Plate Thickness Compensation is set.

IMPORTANT:
After completing this step, click **Next**, and the robot will move for a few inches to perform tilt correction. So, maintain adequate clearance around the robot.

Step 4 **Workspace Calibration**:

Switch the controller to the **Tool** mode under the Cartesian tab of the Controller settings page, and use it to move the robot along the x and y directions so that the red circles on the calibration plate align with the target point (a green circle). Select intended robot poses and click **Record** until the five postures are established.

Step 5 **Save Result:**

Confirm the calibration accuracy and save this result as a workspalce file. This workspace file can be used in fixed-point vision jobs.

4.4.3 EIH Camera Calibration

The external EIH camera can be calibrated using a TMflow project. Make some simple settings for the project and run it; the camera will be automatically calibrated. For the TMflow project, as well as instructions on using the project, please contact your Omron representative for published information.

One robot can only be installed with an external EIH camera. The name of the TCP obtained for a calibrated external EIH camera is **HandCamera2** by default and cannot be changed.

4.4.4 Intrinsic Parameter Calibration for External Camera

This feature allows you to calibrate the intrinsic parameters of external cameras.

Procedure: Place the calibration plate within the camera’s field of view. Click **Capture** and repeat the same step 15 times (with the calibration plate placed at different positions and angles each time). After that, click **Next**.

4.5 Lens Setting

Lens selection has a large impact on image quality. Generally, the lens center is closer to the real image, but the areas around the center are usually not clear enough or bright enough and can be easily distorted. We recommend that when the user chooses a lens, the user should adjust the focus and the aperture based on the size of the workpiece.

4.5.1 Focus / Aperture

The camera kit provides focus and aperture adjustment functions. This can help users adjust an externally connected industrial camera's aperture and focus to the most appropriate position and obtain the clearest image quality. Focus and aperture adjustment page's "Focus Flow" displays the camera's focus status. "Aperture Flow" displays the aperture adjustment status. The X-axis represents the time and the Y-axis represents the focus/aperture score that changes with time. The red line represents the previous highest value. The user can adjust the focus adjustment ring and the aperture adjustment ring on the camera lens to see the values on the corresponding flow change. The user should adjust the aperture and the focus to make the value (black line) reach the maximum value (red line). This is the most appropriate aperture and focus.

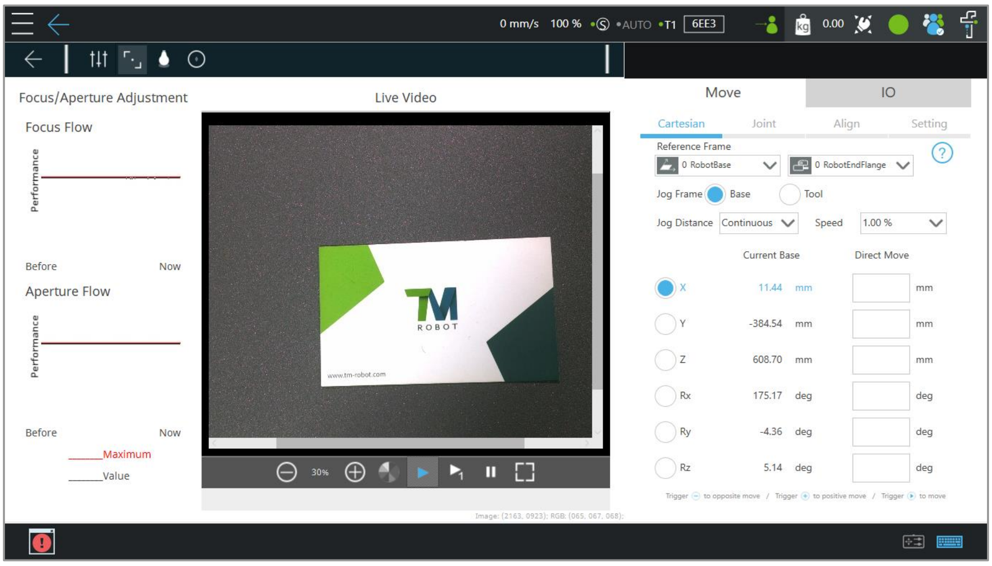


Figure 41: Focus/Aperture

4.6 Eye-to-Hand

Not only can TMvision integrate internal vision, but also match to the supported external cameras to feed the obtained information back to the robot. This operation allows the robot motion to synchronize with image capture and decreases the flow cycle. An illustration of the eye-to-hand camera configuration is as shown below.

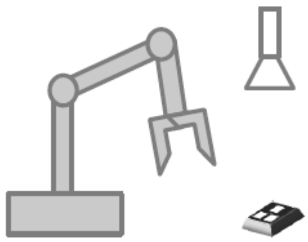


Figure 42: Eye-to-Hand

4.6.1 Pick'n Place

Pick'n Place, as one of the most common uses of Eye-to-Hand, is the fixed position application for the eye-to-hand function. This function uses the establishment of a workspace so that the robot can use the absolute coordinates to calculate and position objects. Its precision is determined by the calibration accuracy of the workspace. For details on fixed positioning and building a workspace, refer to 3.2.1 Object Positioning and 2.2 Vision Base System Positioning Mode. In addition, the external camera can be used to complete more tasks. For example, TMvision can use the external camera to implement "Fixed function" or use the combination of external camera and internal camera to achieve other applications.

4.6.2 AOI / Vision IO

The eye-to-hand module supports the AOI with Vision IO function. For details, refer to 3.2.6 AOI and 3.2.7 Vision IO.

4.7 Upward-Looking

The TMvision upward-looking function uses the relationship between the base and the robot obtained by placing the calibration plate on the object. Command is given to the robot based on the identified feature to move to the object's position of the first upward-looking teaching. This corrects the position deviation of the object caused by claw or suction nozzle instability. In addition, the upward-looking module supports AOI and Vision IO function. The following is an illustration of the upward-looking camera's setting.

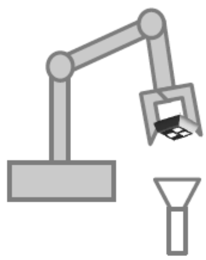


Figure 43: Upward-Looking

4.7.1 Alignment Compensation

The alignment compensation function allows the user to use the upward-looking camera to position the workpiece and to establish a vision tool center. This function compensates the workpiece's X and Y-axis coordinates' deviation and rotation angles' deviation for each item picked. This means that even if the user caused a workpiece deviation during the pick'n place, the robot can still accurately place the workpiece at the correct position.

Step 1: Establish a new vision job and choose the upward-looking module.

Step 2: Select alignment compensation, move to the initial position, and establish object detection.

Step 3: Save job to automatically form a vision tool center.

Step 4: Now the alignment compensation function can be used. Use this vision tool center to establish points. Even if the workpiece grabbing position deviates when moving to the point position, the function can still compensate the workpiece position and accurately move to the correct position.

4.7.2 AOI / Vision IO

The upward-looking module supports the AOI and Vision IO function. For details, refer to 3.2.6 AOI and 3.2.7 Vision IO.

IMPORTANT:

- When calibrating or conducting alignment compensation, pay attention to the stability of the calibration plate or object. If the object or calibration plate moves significantly when the robot moves the object, this object is not suitable for alignment compensation and the object grabbing method needs to be improved.
- Set the tool center position before calibration. The closer the tool center position is to the object plane the more accurate it is.

4.8 Eye-in-Hand

TMvision supports the external EIH camera. The camera can be mounted onto the end flange of a robot, depending on the task at hand, to reduce the cycle time of a project. Each robot can use only one external EIH camera.

The camera supports fixed-point positioning, whereby the robot creates a workspace and use absolute coordinates to calculate and position objects. For details, see 2.2 Vision Base System Positioning Mode and 3.2.1 Object Positioning. OMRON Landmark positioning and AOI identification can also be performe using the camera; for details, see 2.2.1 OMRON Landmark Positioning, 2.2.2 Three-OMRON Landmark Positioning, and 3.2.6 AOI. The setup of the external EIH camera is described in the image below.

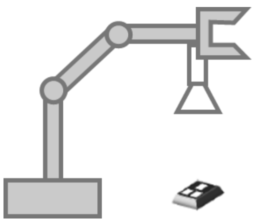


Figure 44: Eye-in-Hand

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