Software Manual
TMvision

Original Instruction

Software Version: 1.68

I627-E-01

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Revision History Table

Revision	Date	Revised Content
01	October 2018	Original release

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 you to experience complete visual software functionalities. The software comes in two functions: Standard and Licensed. The Standard function supports most robot applications, while the Licensed function consists of separate modules that may be purchased as needed.

Widely accepted by many robot vision manufacturers the TMvision comes with such functions as feature identification, object location, enhance mode, barcode identification and color classifier. These diversified functions have been integrated into TMflow's robot control system for you to set up the robot tasks by defining setup steps.

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 you time in getting familiar with robots that you may know little about. For users familiar with robot and machine vision, TMvision comes with a wide range of assistance and integration tools for you 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 the external camera's software and hardware integration, and ends with an introduction of advanced licensed functions.

This manual applies to TMFlow Version 1.68. There will be differences between the functions and interfaces of different software versions. Confirm your software version before using and reading this manual. To confirm your the software version, click the upper right corner of the screen  to open the version information.

1.2 Warning and Caution Symbols

The Table below shows the definitions of the warning and caution levels described in each paragraph of this Manual. 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.

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 “Hardware installation Manual”, “Software Manual”, and “Safety Manual” 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 and Impact Warning Labels

- All personnel who design the robot system must read the “Hardware installation Manual”, “Software Manual”, and “Safety Manual” 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.
- Observing the “Intend of Use” section in “Safety Manual”.
- If the installation and application does not observe human-robot collaboration regulations of the safety regulations, the user is responsible for providing safety barriers around the robot to prevent anyone from accidentally coming into contact with the robot when it is in motion.
- Power to the robot and its power supply must be locked out and tagged out 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 major 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 safety mechanisms based on the results of the risk assessment
- Building appropriate safety mechanisms in the software
- Ensuring the user will not modify any safety-related 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
- Collecting all documents into the technology folder, 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 TM Robot will not cause personnel injury or property damage.

1.6 Functional Note Symbols

The following table defines the functional note symbols marked in each paragraph in this manual. Read the paragraphs carefully to assist the improvement of programming efficiency.

	**REMINDER:** This mark symbol represents the relevant functional details reminder, to assist programming and use.
	**TIPS:** This mark symbol represents the relevant functional use tips, to assist the improvement of programming efficiency.

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 you to execute high precision jobs but also provides high-elasticity for fast line changes. Regarding hardware operation, users shall move the arm right above the object and press the Vision button on the camera to generate a Vision node on the TMflow for subsequent visual job programming. See "Hardware Installation Manual" of relevant hardware for position of relevant buttons.

TMvision is designed for base system calibration and vision jobs; it enables users to tune parameters for visual features screening based on light sources and image features in the Vision node, thereby improving the performance of visual identification. See subsequent chapters for more details on settings and instructions.

2.2 Vision Base System Positioning Mode

The TM Robot's built-in Vision Designer is 2D camera based. It supports aligning models based on object-oriented or arm alignment-oriented base systems. The object-oriented base system requires a workspace to ensure the camera created workspace's paralleling with the robot. Failing to keep the two in the same workspace may lead to distorted imaging and visual identification failure. TMvision offers four positioning modes: TM Landmark, fixed-point positioning, servoing, and object-based calibration. These methods shall be described below.

2.2.1 TM Landmark

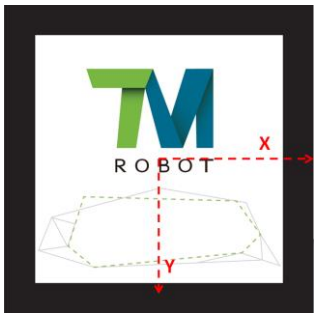
TM Landmark provides a fast, simple and flexible base system positioning function for users to attach it to the environment. Shooting TM Landmark with TM Robot will end up with positioning the information of six degrees of freedom (including X, Y, Z, RX, RY, RZ) in one shot. A base system will be added accordingly for users to define subsequent points and motions based on it. For robot operations after the relative positions between TM Robot and TM Landmark have changed: have the robot shoot the TM Landmark again to renew its six degrees of freedom information, i.e. get the Landmark base system information updated. Note that the point and motion data recorded in the Landmark base system will auto change their base system to enable the robot to move to the same position once again.

TM Landmark is a 0.2 cm thick and 5x5 cm square plastic plate as shown in figure below. By capturing and recognizing TM 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 TM

Landmark's black and white border. Note that it's impossible to attach the TM Landmark precisely to the environment and identification and alignment cannot rely on this physical frame, which has no reference value for mechanic alignment. In principle, TM Landmark is not designed to let you directly run to individual points or execute motions after creatinga base system. Instead, it is an alignment tool to lead the robot toward a valid visual point. Users shall use the TM Robot visual positioning function to identify and locate the actual object in the last step to get the best results.

The TM Landmark can generate coordinate information of six degrees of freedom. Valid data in the RX, RY, and Z directions is hard to attain through existing EIH 2D vision (i.e. camera plane parallel with that of the object and distance in between the two). The TM Landmark enhances the positioning capacity of 2D vision along these axes. Though TM Landmark is capable of getting information on the X, Y, and RZ directions, users may fail to attach TM Landmark accurately in an operation environment. They are not recommended to use TM Landmark for positioning. As these three degrees of freedom are the coordinate information required by EIH 2D visual for positioning compensation, users shall use the two together, Users must correct the relative relationship of robot with relevant machines and RX, RY, and the Z axis of the environment by the TM Landmark. That is, aligning of TM Landmark along the three axes ensures the visual points are recorded in the TM Landmark base system. After updating the camera posture in the TM Landmark base system, it may be reset parallel with workpiece features (RX, RY), reset to correct distance to workpiece features (Z), and be ready for subsequent 2D vision jobs. Now you can use individual 2D aligning functions of TMvision to align the remaining axial directions of X, Y and RZ. Even in case the relative position between base of robot and the TM Landmark changes you may re-effect the point and motion recorded in the landmark base system of the original project by having the robot shoot the TM Landmark once again.

When programming a project, users may place TM Landmark in the target task environment and create a TM Robot vision job and subsequent motions with the base system. Shooting the TM Landmark again in later operations will enable the robot to auto-reset to the original base system, i.e. to change alignment of robot according to site conditions without being confined to a fixed alignment.

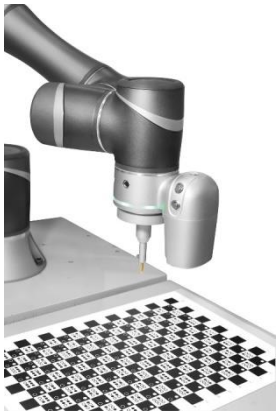


Note

TIPS:
The farther away of TM Landmark 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 TM Landmark. A shorter distance in between the camera and Landmark has the advantage of better aligning accuracy but comes at the cost of a smaller field of view and Landmark's easy falling out of vision. Users are advised to edit 2 vision jobs, the one nearer and the other farther, when using TM Landmark. The farther one is aimed to quickly detect the TM 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 TM Landmark 10cm apart from each other. Shoot the same TM Landmark to get a more accurate Landmark base system.

2.2.2 Fixed Positioning

The fixed positioning function is designed with a pre-set object placement area and pre-set height for vision jobs. Users may create a workspace with the TM calibration plate. When using the TM calibration plate for fixed-point aligning, the relative height of the Vision Designer and the work plane is also defined. When using fixed-point aligning to establish a workspace, users shall ensure that the absolute height of camera and object must be equal to the workspace created by the TM calibration plate. See Chapter 2.6 Calibrate Workspace for details on creating workspace.



2.2.3 Servoing

TMvision also provides servoing functions for users to define object characteristics. In later servoing process the TMvision auto adjust robot arm position based on the operation defined to give the relative position of the camera and object.

2.2.4 Object-based Calibration

The object-based calibration is basically "Teaching as Servoing, result as fixed-point positioning". Execute tilt-correction with calibration plate; servoing actual workpiece to define workspace; compute converting into fixed point positioning. As servo calibration is used only when defining a workspace for the first time, the robot shall place the object at the four corners of the camera field of view through four movements to create the workspace; the latter shall be used in fixed point visual computing later. This balances the benefits of the fixed positioning's time saving when running positioning identification and calibration plate free calibration similar to that of servoing. Select object with the feature of moderate size for easy object-based calibration or the image feature to prevent image features being beyond the field of view during servo calibration.

2.3 Camera List

List of cameras on the left side of TMvision shows cameras in use and their status. Right-click the menu to pop up a list of refresh menus and GigE camera detection.

2.4 Controller

To facilitate the user's control of arm movements, the TMvision System Interface also provides an interface for robot movement control. The user may use the controller to move arm to appropriate position to edit subsequent vision jobs.

2.5 Camera Kit

The camera kit is used to adjust camera imaging, including camera parameter setting, focus / aperture, brightness setting, and tilt-correction.

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 external camera: it provides visual tools for easy regulation. Users may read scores of 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.
Brightness Setting	Includes illuminance visualization tool to enable users adjusting lighting tools for optimized illumination distribution. The left side set up sensitivity of the visualization tool. The two trackbars in the settings indicate the lower and upper limits of the visualization display. The brightness over the lower and lower limits shall be defaulted to either limits for display. If the illuminance in field of view is uniform, colors shown by visualization tools may remain close to each other in case of high sensitivity (upper and lower slides being farthest away from each other).
Tilt-Correction	Secure TM Landmark or calibration plate to the target plane as a calibration tool to enable the arm's auto adjustment to the tilt angle and paralleling the camera to target plane. Adjust camera parameter settings to ensure TM Landmark or calibration plate 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.

2.6 Calibrate Workspace

2.6.1 Automatic Calibration

Workspace calibration enables users to create workspaces for fixed-point vision jobs including automatic and manual calibrations:

The dynamic workspace calibration has four steps: 1. Tilt-Correction; 2. Confirm Workspace; 3. Automatic Workspace Calibration; 4. Save Results

TIPS:
Before starting calibration: Position the identification target in the center of the field of view with the controller or manual handle. Place the camera 10 to 30 cm above the target. Determine the plane where the feature is located before placing the calibration plate on the plane. In case the workpiece geometry does not allow for a calibration plate, you may replace the workspace with an object of the proper height to fix the calibration plate at the same height as the identification feature.

REMINDER:
Keep adequate clearance around the robot as in an automatic calibration process the robot will move around the initial position.

Once well prepared, keep away from and do not shake the calibration plate and start the calibration process.

Step1. Tilt-Correction: Correct tilt before correcting workspace calibration to ensure the calibration plate is parallel to the camera.

Step 2. Confirm Workspace: Visual check tilt-correction. Click the icon in flow chart to calibrate tilt again if necessary. The robot shall be positioned at the initial position of the robot of this workspace.

Step 3. Automatic Workspace Calibration: Click Start, the robot takes pictures of calibration plate in multi-angles to calculate workspace position relative to the one defined by the calibration plate. When executing fixed position features identification the workspace created by calibration plate shall serve as the reference plane to identify the position of the features point on the reference plane.

Step 4. Save Results: Once the accuracy has been validated, save the calibration results in a workspace file to access it in fixed vision jobs.

2.6.2 Manual Calibration

The manual workspace calibration has four steps: 1. Confirm Workspace; 2. Set Calibration Tool; 3. Calibrate Workspace; 4. Save Results

TIPS:
Before starting calibration: Mount required calibration tools on flange surface of the robot, and use calibration set provided by Techman Robot as the calibration tool. The latter shall be subject to TCP to get its actual installation position value. Once installed, position the identification target in the center of the field of view with the controller or manual handle; place the camera 10 to 30 cm above the target; determine the plane where the feature is located before placing the calibration plate on the plane. In case the workpiece geometry does not allow for a calibration plate, you may replace the workspace with an object of the proper height to fix the calibration plate at the same height as the identification feature.

REMINDER:
Once well prepared, do not shake the calibration plate and start the calibration process.

Step 1. Confirm Workspace: The robot shall be positioned at the initial position of the robot of this workspace.

Step 2. Set Up Calibration Tool: Select the tool center point shape compliant with the calibration tool selected

Step 3. Calibrate workspace: Point the calibration tool to the calibration plate grid shown on the screen when being prompted, click Next, repeat this step for five times. Use the controller to manipulate the robot arm when running this operation.

Step 4. Save Results: Once the accuracy has been validated, save the calibration results in a workspace file to access it in fixed vision jobs.

2.7 Live Video

Live Video provides instant camera image. Its functions are accessible on the tool bar at bottom of page (from left to right): Zoom out, current display ratio, zoom in, text color, Play, Play Once, Pause.

Applications	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.
Text color	Set color of text shown on the image. Change font color for easy identification when it is too close to the image itself.
Play, Play Once, Pause	Set up extract mode (default = continuous extract) to ease user's current image shown on camera; pause extract: to freeze image and stop capturing; extract once: to get current image when pressing the extract button.

2.8 Task Designer

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

2.9 HardDisk Setting

The TM HardDisk setting provides users with the ability to manage photo storage space and require optional TM SSD. The latter saves identified or raw images for analysis in future.

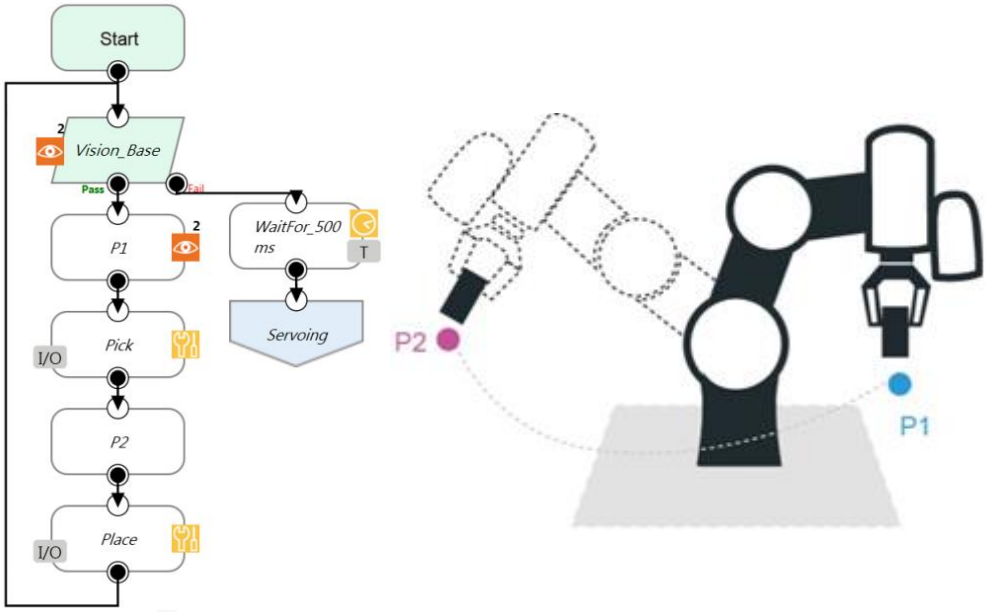
The pie chart in the lower left corner of the interface tells used space, available space, and reserved space. Users may set up path of storage file and size of reserved storage space in this page. You may select to stop saving photos or deleting the oldest ones when out of free space.

3. Task Designer

3.1 Overview

TMvision contains the following task designer functions: Fixed, Servoing, AOI-only, Vision-as-IO, Landmark Alignment, and Object-based Calibration. Users can select the required applications according to their needs and execute jobs with diversified visual algorithm.

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



(Pick & Place)

REMINDER:
When using a vision base system, select the current base system shown on the upper right corner of TMflow as the vision base system.

TIPS:
In case of invalid selection, re-record the base system with the "Re-record in other base system" by the role of Point Manger.

3.2 Select Application

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

Applications	Suitable for hand-eye relationship	Workspace	Base system output
Fixed	Eye-in-Hand / Eye-to-Hand	✓	Create base system based on object position
Servoing	Eye-in-Hand	×	Create base system based on arm position
AOI-only	Eye-in-Hand / Eye-to-Hand	×	×
Vision-as-IO	Eye-in-Hand / Eye-to-Hand	×	×
TM Landmark Alignment	Eye-in-Hand	×	Create base system based on Landmark position
Object-based Calibration	Eye-in-Hand	×	Create base system based on object position

3.2.1 Servoing

Enter the TMvision Task Designer window and select servoing to use this function. Servoing is only suitable for eye-in-hand. Alignment is achieved by getting continuously closer to the object's target coordinate on the image. Thus, the workspace does not need to be established. If change in the target angle is greater, then use a calibration board to conduct level calibration during the initial aligning. The servoing time is determined by the convergence interval and the arm movement path. This can be applied to situations where the relationship between the camera, workspace, and arm can easily change due to changes in human action and the environment. After the level is calibrated, select the INITIATE on the left side of the Flow to conduct basic parameter settings. Setting parameters are as follows:

Name	Function
Adjust camera parameters	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.
Switch to record image	Use the internal TM SSD images for identification.
Start at initial position:	Check this to return the arm to its initial position before visual identification. Uncheck this and the arm will execute visual identification at the current position.
Lighting	Control light source switch at end of the arm.
Move to the initial position	Move the arm to the initial position
Reset initial position	Reset initial position of arm
Waiting time for the arm to stabilize	This is the waiting time from when the arm moves to the alignment to the time the picture is taken. Manual or auto setting can be selected.

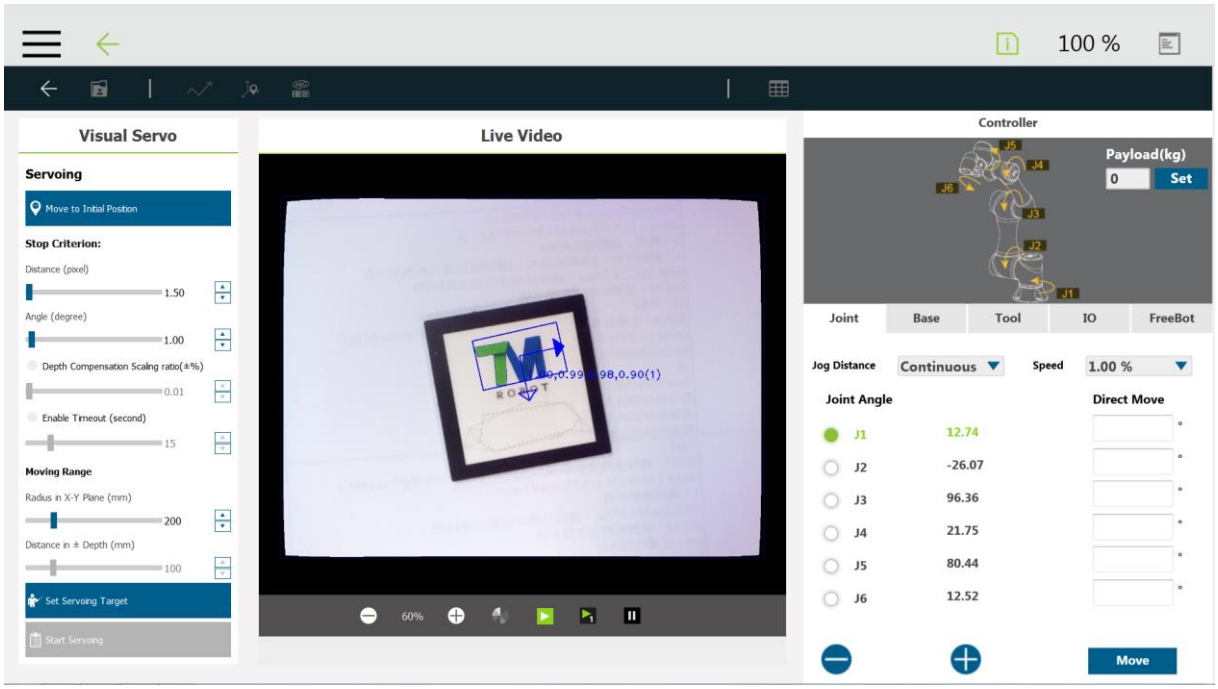
After the basic parameters have been set, confirm that the image is clear and can be seen. Select the "Find" module at the top and use the pattern matching function to match the pattern's shape feature in the selected frame.

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 from the same object.

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

Note

TIPS:
TMvision provides an easy feature editing function. In case patterns selected contain unnecessary features users can click "Edit pattern" icon to modify features of the pattern.



Parameters of the teaching page are described below:

Name	Function
Move to the initial position	Move the arm to the initial position
Distance (pixels)	When features distances between current and target object go shorter than the value, it is judged convergent.
Angle	When features angles between current and target object go lower than the value, it is judged convergent.
Depth compensation	Whether or not to perform depth compensation based on the Scaling value of identification result.
Radius in X-Y plane	Stop arm movement when the horizontal movement distance exceeds this value.
Distance in ± depth	Arm movement stops when vertical movement distance exceeds this value.
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 object. Only save the results after successful servoing.

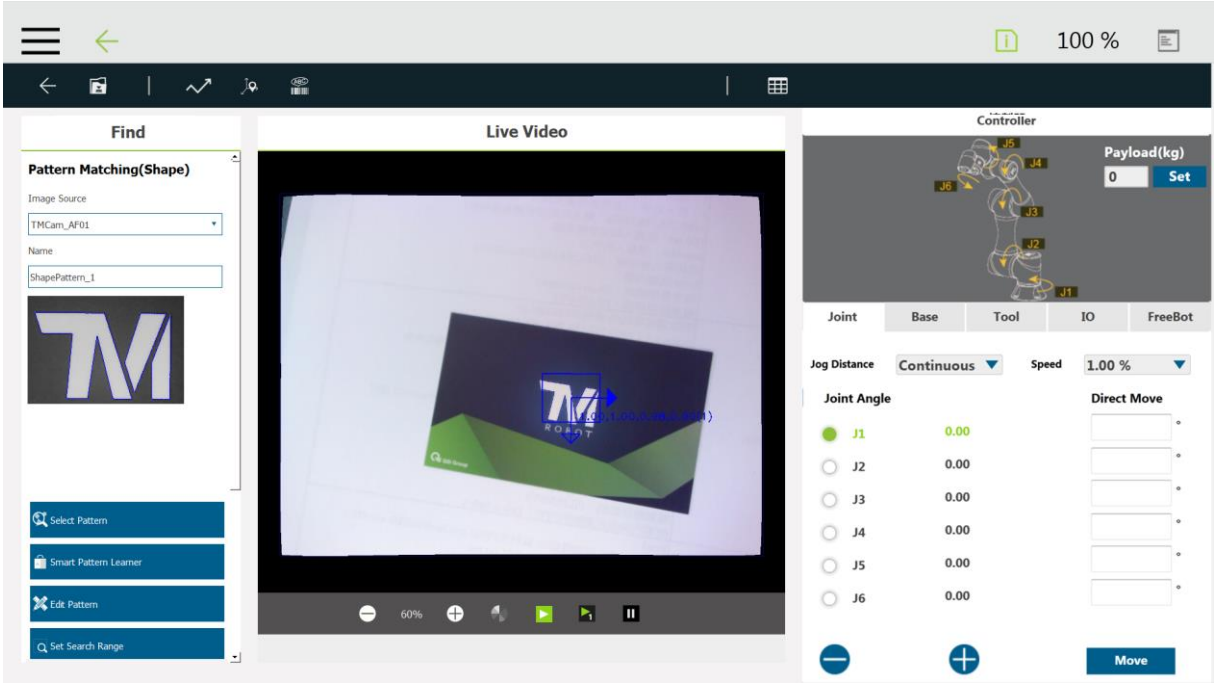
After the servoing target setting has been completed, click Start Servoing and press the (+) button on the robot stick; TM Robot then servoing the visual screen; save the results once the TMvision prompts servoing completed successfully.

3.2.2 Fixed Positioning

Enter the TMvision Task Designer window and select Fixed to use this function. The fixed positioning function is designed for hand-in-eye and hand-to-eye for the robot to calculate and position objects with absolute coordinates by creating a workspaces. Its accuracy varies with that of workspace calibration. See 2.2Vision Base System Positioning Mode for details on creating workspace. After choosing the workspace, use INITIATE in Flow on the left side to set basic parameters. Setting parameters are shown below:

Name	Function
Adjust camera parameters	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.
Switch to record image	Use the internal TM SSD images for identification.
Start at initial position:	Check this to return the arm to its initial position before visual identification. Uncheck this and the arm will execute visual identification at the current position.
Lighting	Control light source switch at end of the arm.
Move to the initial position	Move the arm to the initial position
Reset workspace	Can reset the arm's workspace
Waiting time for the arm to stabilize	This is the waiting time from when the arm moves to the alignment to the time the picture is taken. Manual or auto setting can be selected.

After the basic camera parameters have been set, select the "Find" module at the top. Select the pattern matching function as shown below. The TMvision will use the framed shaped feature to find its alignment on the image, and then build the visual base on the object.



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 difference in between as well as give scores for similarity determination. Users may set up appropriate thresholds to determine whether the two images are from the same object. Save the results once the object is validated "Object is detectable and only ONE object is detected".

Note

TIPS:
TMvision provides easy feature editing function. In case patterns selected contain unnecessary features users can click "Edit pattern" icon to modify features of the pattern.

3.2.3 AOI-only

Enter the TMvision Task Designer and select the AOI-only to use this function. The AOI-only identification is applicable to EIH or ETH for you to read the barcode, QR-code and color classification, etc, without workspace and base system output. Make sure there is only one clear and readable barcode in the framed region. When identifying a barcode, use INITIATE on the leftside Flow to set basic parameters, The setting parameters are shown below:

Name	Function
Adjust camera parameters	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.
Switch to record image	Use the internal TM SSD images for identification.
Start at initial position:	Check this to return the arm to its initial position before visual identification. Uncheck this and the arm will execute visual identification at the current position.
Lighting	Control light source switch at end of the arm.
Move to the initial position	Move the arm to the initial position
Reset initial position	Reset initial position of arm
Waiting time for the arm to stabilize	This is the waiting time from when the arm moves to the alignment to the time the picture is taken. Manual or auto setting can be selected.

After setting the basic parameters, choose the pattern matching function in the "Find" module at the top to proceed with matching. The identification is only for a specific region and not for the entire visual field. Thus, the user can use the "Find" module to change the identification region, then use the corresponding relationship with the initial alignment to find the object feature. Once the object feature is found, the object's barcode can be accurately determined. The barcode identification will output the identification result. The Display node can be used to confirm whether the accurate barcode has been obtained.

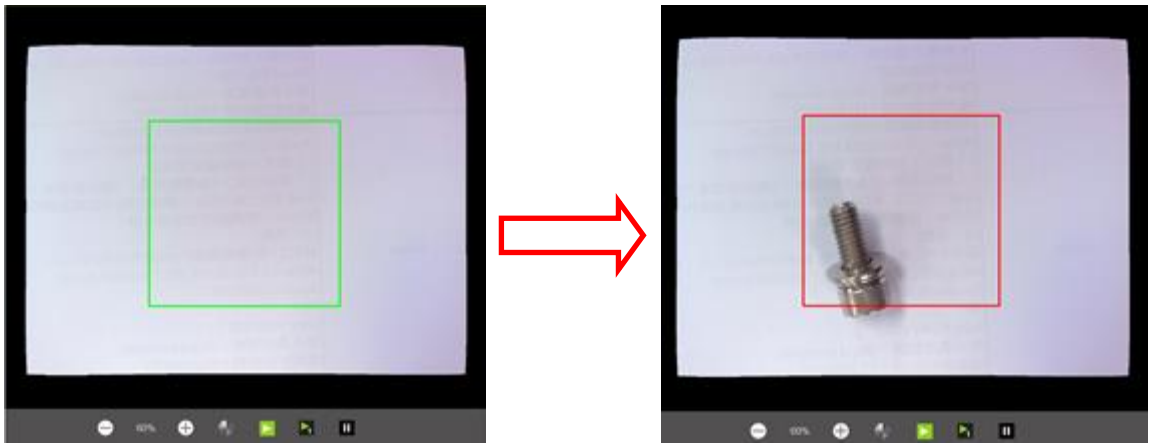
3.2.4 Vision-as-IO

Enter the TMvision Task Designer window and select the Vision-as-IO Only to use this function. When an obvious change occurs to 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 the TMflow.

Startup method:

Task Designer→Vision-as-IO

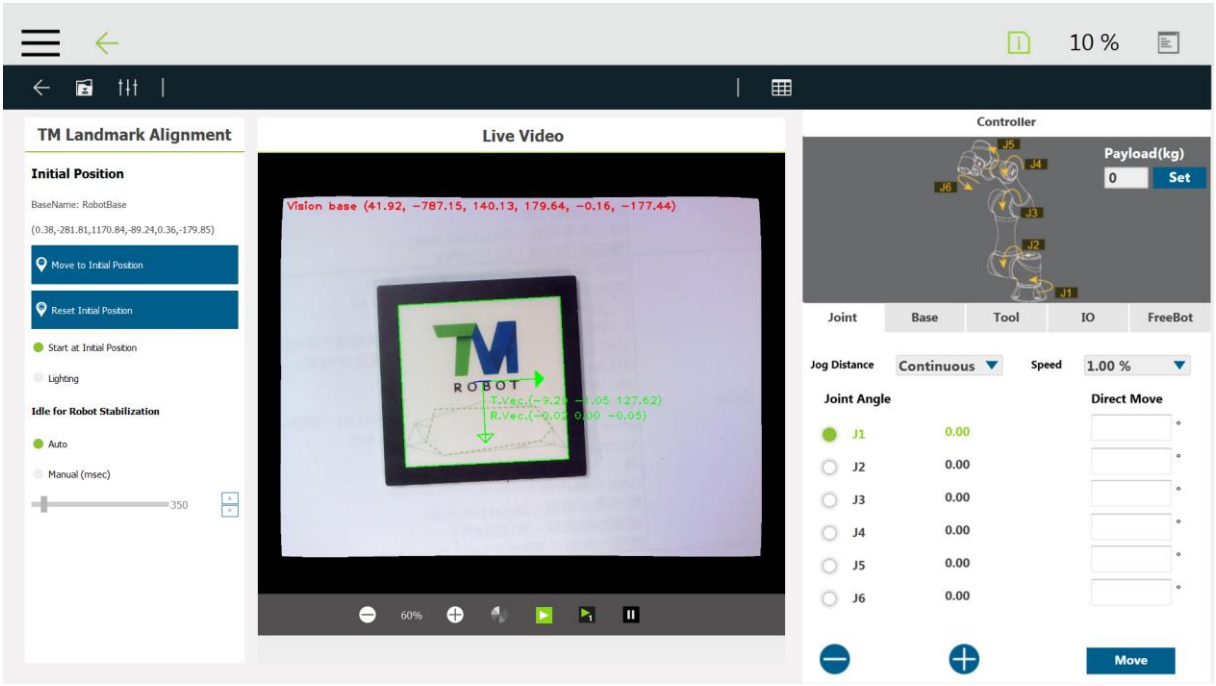
Relative to the aforementioned process vision jobs pages as shown on the left prompted for setup when users select Vision IO at startup.



Name	Function
Move to the initial position	Move the arm to the initial position
Reset initial position	Reset initial position of arm
Set sensing window	Popup windows below for users to set up monitoring area. Variation in the latter over Threshold settings suggests that a trigger event occurred.
Arm pausing time	Can set the time waiting for Vision-as-IO. If the IO is not activated within the time limit, the process moves towards the Fail exit.
Threshold	Trigger event sensitivity: The lower the threshold, the more sensitive.

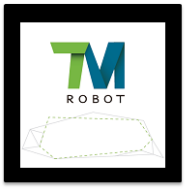
3.2.5 Landmark Alignment

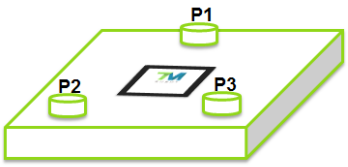
Enter the TMvision Task Designer window to select and use the Landmark Alignment function. Users may run this function with the official TM Landmark. This is aimed to base subsequent teaching point on the base system added by Landmark.



For point recorded on the robot base: Re-teach all points once the relative relationship between arm and object has changed.

If the vision base system is created through Landmark and the aligning point is based on the aforementioned vision base system, in case the arm relationship changed the goal of Easy-to-Deploy may be reached by the executing visual node and updating Landmark vision base system.





The Landmark Alignment can be divided into Fixed and Servoing. The servoing parameter settings are as follows.

Name	Function
Move to the initial position	Move the arm to the initial position
Reset initial position	Reset initial position of arm
Start at initial position:	Check this to return the arm to its initial position before visual identification. Uncheck this and the arm will execute visual identification at the current position.
Lighting	Control light source switch at end of the arm.
Radius in X-Y plane	When the horizontal moving distance exceeds this value, stop arm movement.
Distance in ± depth	When the vertical moving distance exceeds this value, stop arm movement.
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 object. Only save the results after successful servoing.

Fixed parameters are shown below. We recommend users to use the Fixed option for the optimal alignment.

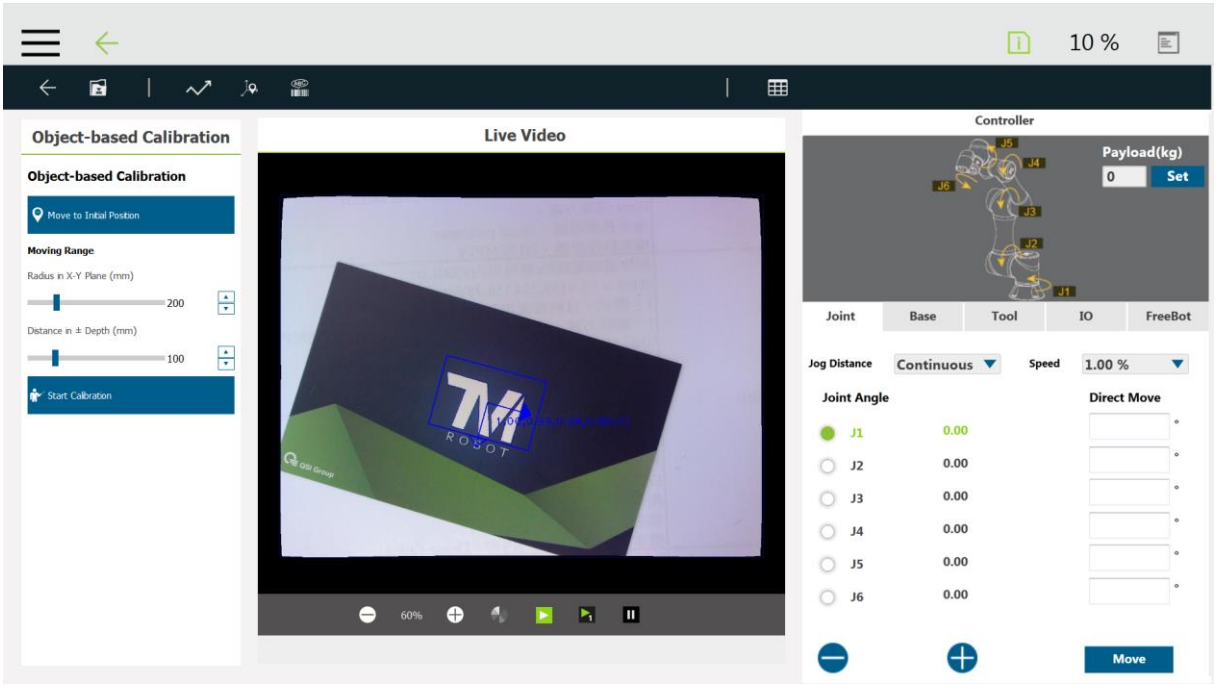
Name	Function
Move to the initial position	Move the arm to the initial position
Reset initial position	Reset initial position of arm
Start at initial position:	Check this to return the arm to its initial position before visual identification. Uncheck this and the arm will execute visual identification at the current position.
Lighting	Control light source switch at end of the arm.
Waiting time for the arm to stabilize	This is the waiting time from when the arm moves to the alignment to the time the picture is taken. Manual or auto setting can be selected.

3.2.6 Object-based Calibration

The object-based calibration is validated for EIH. It employs the difference in arm servoing movement to calculate relative relationship in between object and arm without workspace creation. In case the positioning target angle may suffer larger variation, execute horizontal calibration with calibration plate before determining the initial position. This function delivers very good accuracy for objects with simpler geometry, as the fixed-point base system directly built on the object comes without height differences due to the calibration plate. After the horizontal calibration has been completed, click above the "Find" module for TMvision to frame the shape feature with pattern matching function.

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 from 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.



Note

TIPS:
TMvision provides an easy feature editing function. In case patterns selected contain unnecessary features users can click "Edit pattern" icon to modify features of the pattern.

Name	Function
Move to the initial position	Move the arm to the initial position
Radius in X-Y plane	When the horizontal moving distance exceeds this value, stop arm movement.
Distance in ± depth	When the vertical moving distance exceeds this value, stop arm movement.
Start calibration	Click and hold to run the (+) button on the robot stick to servo the object. The robot shall 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 ended the aforementioned actions.

3.3 Function list

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

3.3.1 Enhance

Image enhance module provides multiple functions to enhance image features and improve successful project identification in special application environment.

Function module	Function description
Contrast enhancement 	Adjust image contrast.
Color plane extraction 	Can obtain specific colors (such as red, blue, or green) or saturation.
Smoothing 	When the image source has noise, this module can be used to filter out the noise and increase the image's smoothness.
Thresholding 	Transform raw image into a black/white one.
Morphology 	Can erode, dilate, patch, or open the image.
Image flipping 	This module can be used to flip the image.

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.

When the contrast between the region of interest (ROI) against the background is poor, you may enhance it with this module to improve the success rate of object comparison. Users are advised to maximize difference in 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.

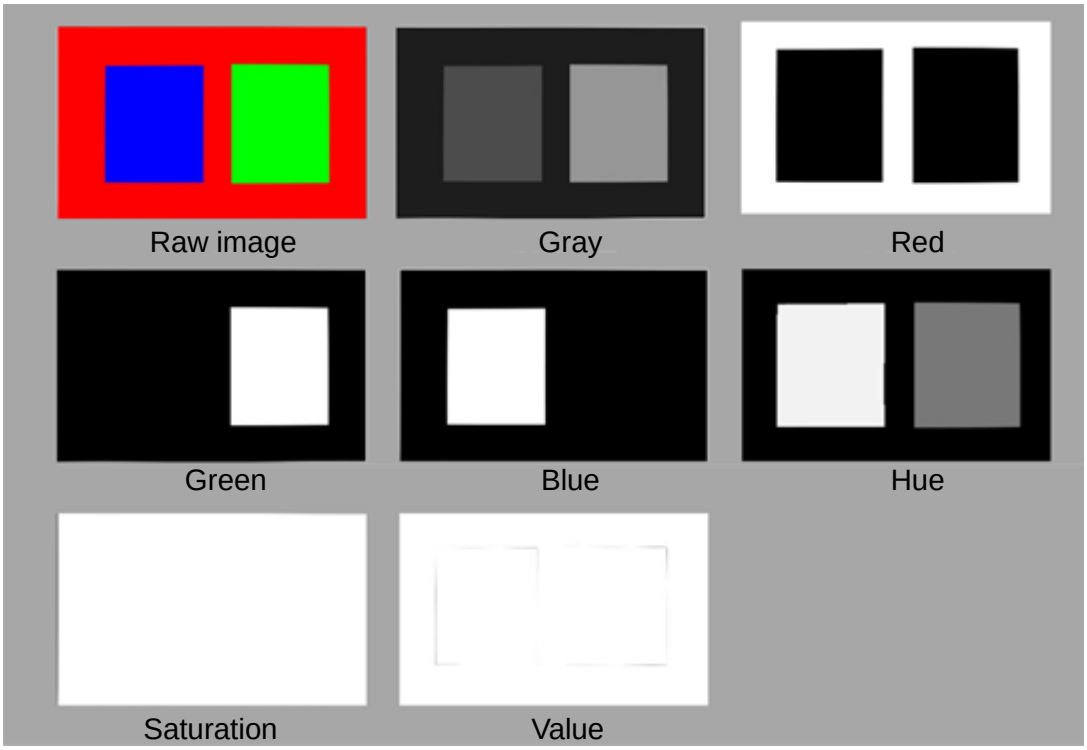
Enhance settings	Function description
Image source	Switch among source image modules
Contrast	Adjust contrast. If adjust as -1, then the result is a reverse image (negative).
Brightness	Adjust brightness
Gamma	Adjust image gamma value
Reset	Reset parameters
Color plane	Select specific color plane for adjustment.
Lookup Table	Conversion curve for the input and output
Histogram	Image's histogram

3.3.1.2 Color Plane Extraction

User can extract a specific color plane from an image or convert it from RGB space to HSV space. Express through the different color planes between the object and the background. Choose appropriate color plane to increase the contrast between the object and the background, and improve the object's detection accuracy.

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

Enhance settings	Function description
Image source	Switch among source image modules
Color plane	The color plane to extract: - Gray - Red - Green - Blue - Hue - Saturation - Value
Histogram	Image's histogram



3.3.1.3 Smoothing

Enhance settings	Function description
Image source	Switch among source image modules
Filter type	Select filter type: - Mean Filter - Gaussian filter - Median filter
Mask size	Regarding mask size: larger mask size shall result in a smoothing effect in a greater region where the median filter shall adjust width parameters only.

3.3.1.4 Thresholding

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

Enhance settings	Function description
Image source	Switch among source image modules
Threshold type	Binary: Higher than threshold, set as white. If lower, then set as black. Binary (Inverted): set to black if over threshold value. Otherwise, set to white. Truncated: Higher than threshold value, set equal to threshold. To Zero: Lower than threshold value, set as zero. To zero (inverted): reset values over the threshold to zero

3.3.1.5 Morphology

Morphology computing is often applied to binarize images closing or opening effect to current image for noise removal or connecting broken foreground objects.

Enhance settings	Function description
Image source	Switch among 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: Deduct image after erosion from the one after dilation to single out the edge area.
Structuring element	Rectangle Cross Ellipse
Element size	Operands of larger size would apply morphological computing in a larger area
Iteration	Number of repeated operations

3.3.1.6 Image Flipping

This module can be used to flip the image.

Enhance settings	Function description
Image source	Switch among source image modules
Rotation Direction	Vertical, horizontal.

3.3.2 Find

Function module	Function description	Output (floating point)
Pattern Matching (shape) 	The object geometry based object detection function locates the object's shape features in the image.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
Pattern Matching (image) 	Locate 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).
Fiducial Mark Matching 	Use the two obvious feature regions on the object for alignment.	Relative to coordinates X, Y and rotation angle R of image home (upper left).
Blob Detection / Blob Finder	Identify foreground object by color difference between the object and the background.	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).

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 light indicates the one after successful computing. The orange light indicates the one of failed computing.

REMINDER:
The project can be saved only when none of the process is of orange color light indicator.

3.3.2.2 Shape Pattern Matching

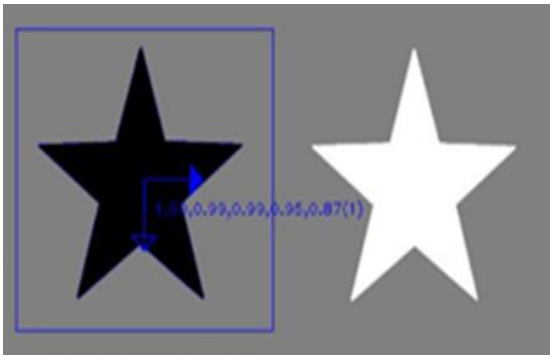
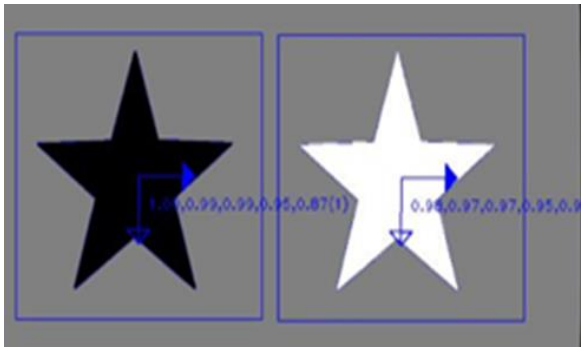
The module uses the geometrical shape of the object as its pattern model and matches it to the input image to align the object in the image. It supports variations due to object rotation and dimension. It is more applicable for application with rigid profiles.

Name	Function description
Pattern Selection	After selection, this image will pop out. Users can select the object in the image.
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 the threshold, internal distance, and external distance. Step 5: Press Next to exit the Smart Pattern Learner.
Pattern editor	Click and the edit window pops up for you to edit shape feature of the object.
Set search range	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range. Improve identification efficiency by setting up a reasonable identification scope in Set Search Range.
Num. of Pyramid Layers	Pyramid Layers: More layers shall result in shorter searching time. For workpieces with more details, the latter may get discarded and lead to detection errors.
Min. Score	Object can be determined only when the score of the detection result is higher than the minimum setting.
Max. Num. of Objects	The maximum number of objects that can be detected in the screen.
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.

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

REMINDER:
Num. of Pyramid Layers is directly linked with speed of pattern matching computing. The latter matches in layers from top down. Pixel resolution halves for every extra layer while the searching speed soars. 3-5 layers are a commonly adopted value. Users may set up according to features of pattern edge feature. Set fewer layers in case of more feature details. Otherwise set more layers to cut computing time.

REMINDER:
Smaller minimum scores reduces "missing judgment" at the cost of more misjudgments. Commonly used values fall between 0.5 and 0.7.

Pattern	
	
Check Directional Edge	Uncheck Directional Edge
	

TIPS:
The pattern matching algorithm determines matching of object based on strength and direction of object edge. Edge direction refers to whether the edge is from shallow to deep or from deep to shallow. When the parameter of a directional edge is checked, the latter shall influence the identification output (stars on the left side get detected). Otherwise, both starts will be detected.

3.3.2.3 Image Pattern Matching

This module 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 description
Pattern Selection	After selection, this image will pop out. Users can select the object in the image.
Set search range	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range. Improve identification efficiency by setting up a reasonable identification scope in Set Search Range.
Num. of Pyramid Layers	More layers menas that the search time can be significantly reduced. However, if the workpiece has too many details, the details can be easily erased and cause detection errors.
Min. Score	If the score of the detection result is higher than this minimum score, the system will determine this as the object.
Max. Num. of Objects	The maximum number of objects that can be detected in the screen.
Similarity Metric	Users can pick the most appropriate measuring method from among the "Correlation Coefficient" or "Absolute Difference" methods. 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.

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

REMINDER:
Num. of Pyramid Layers is directly linked with the speed of pattern matching computing. The latter matches in layers from the top down. Pixel resolution halves for every extra layer while the searching speed soars; 3-5 layers are a commonly adopted value. Users may set up according to features of pattern edge feature. Set fewer layers in case of more feature details. Otherwise, set more layers to cut computing time.

REMINDER:
Smaller minimum scores reduces "missing judgment" at the cost of more misjudgments. Commonly used values fall between 0.5 and 0.7.

3.3.2.4 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 suffers from a smaller search range and poorer successful rate when object 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 description
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 the most appropriate measuring method from among the "Correlation Coefficient" or "Absolute Difference" methods. The former has a slower speed, but is tolerant of ambient light differences, and the light and shadow changing ability is stronger.

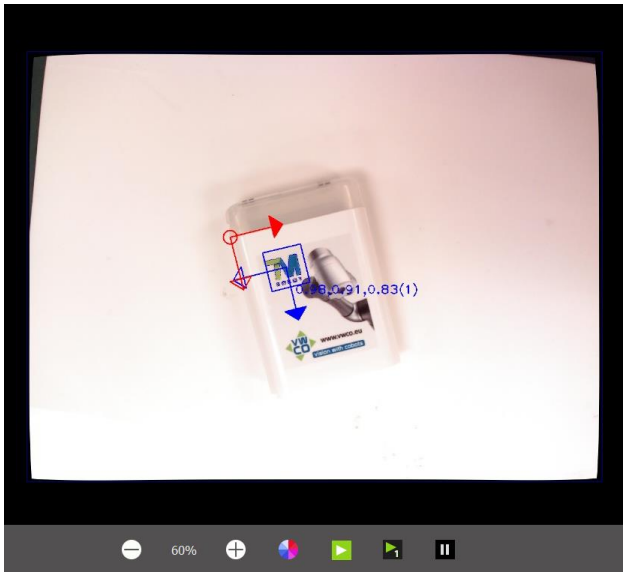
3.3.2.5 Blob Detection / Blob Finder

Differing from detecting workpiece of fixed geometry by pattern matching, those without fixed geometry shall rely on this module for detection.

Name	Function description
Set search range	Set effective detection range
Color plane	Choose color space to use
Extract color	Click and enclose color of ROI on image.
Red, green, blue Plane	Distribution range of ROI color
Area size	To set up area of foreground scope: Regions with points of foreground pixel group fall beyond the scope shall be discarded.
Max. Num. of Objects	The maximum number of objects that can be detected in the screen.
Sorted by:	When the maximum number of objects is greater than 1, the outputs will be sorted according to the setting of this field.

3.3.2.6 Anchor

The anchor module is aimed to change initial position and orientation of the object base system. When finding objects with a "Find" module, the default base system is blue arrow marked. You may connect an anchor point to the process to change home and orientation of the base system, e.g. set home at vertex of upper left corner and parallel to the black frame.



Name	Function description

Manual adjustment	Manually drag the anchor point to the target position.
X direction shift (pixels)	Change the anchor position to the X direction of home point.
Y direction shift (pixels)	Change the anchor position to the Y direction of home point.
Rotation	Change the anchor of home point.

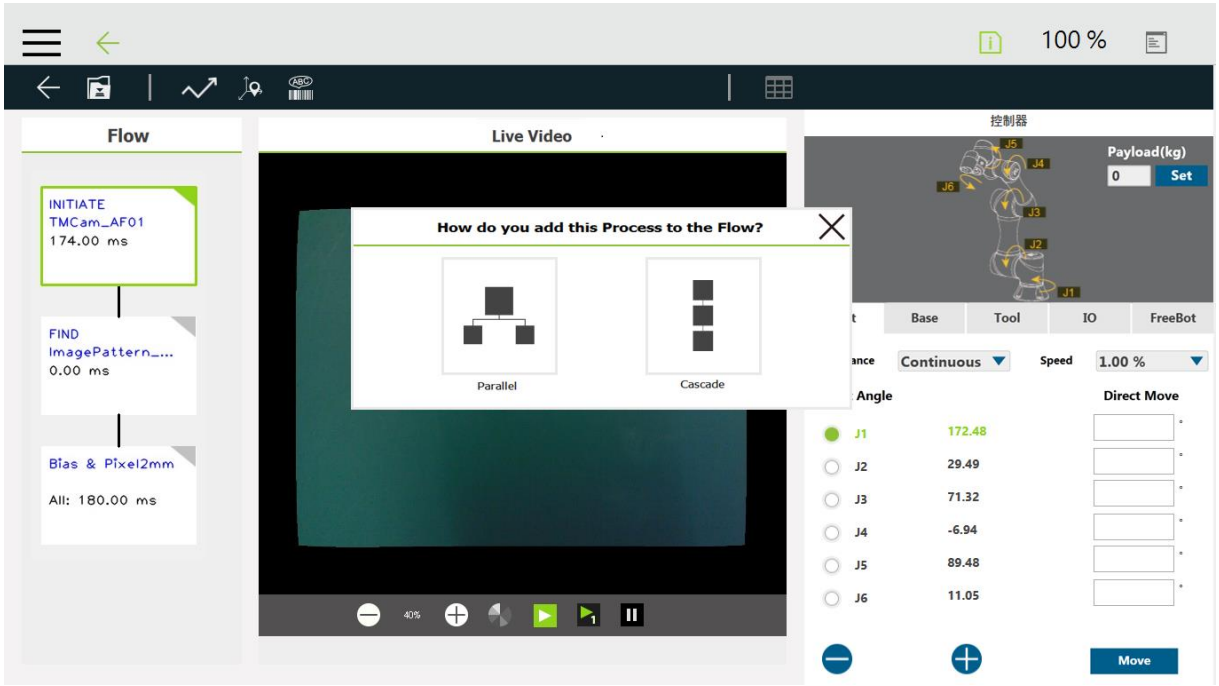
3.3.2.7 One Shot Get All

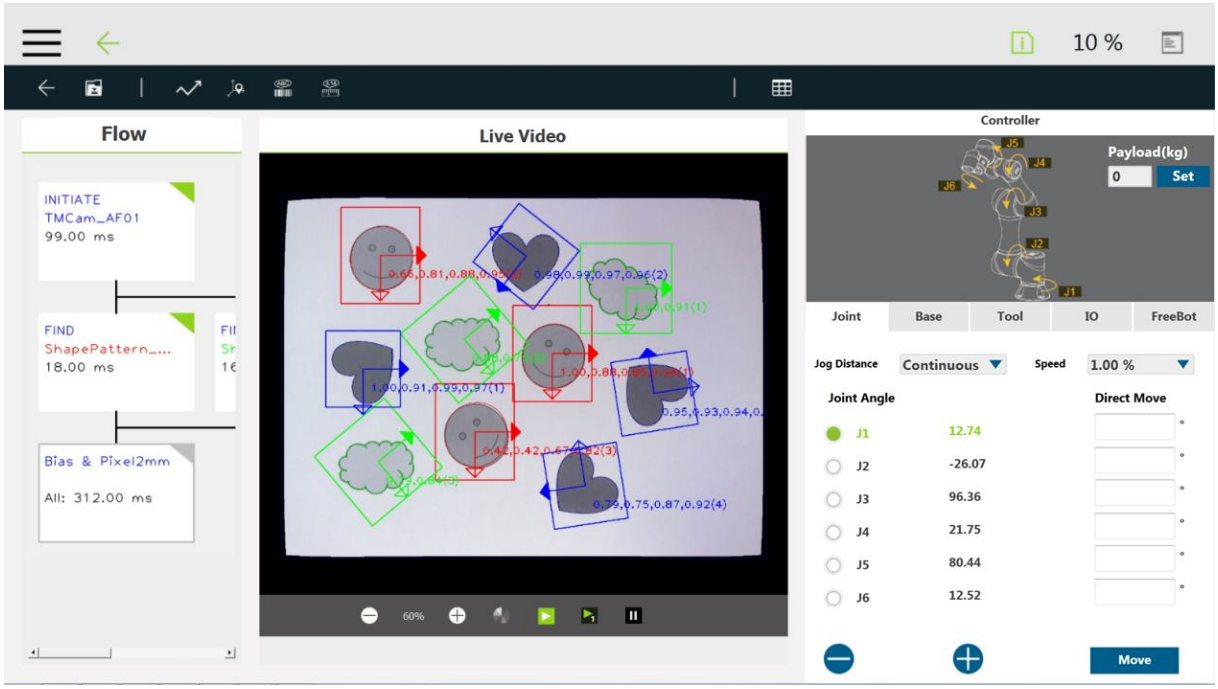
This function creates multiple sets of independent processes for one visual task. It outputs multiple-object and multiple-set of identification report with one shooting. This saves a lot of repeated computing time as only one shot is required.

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

Step 1: Create a visual object search module process

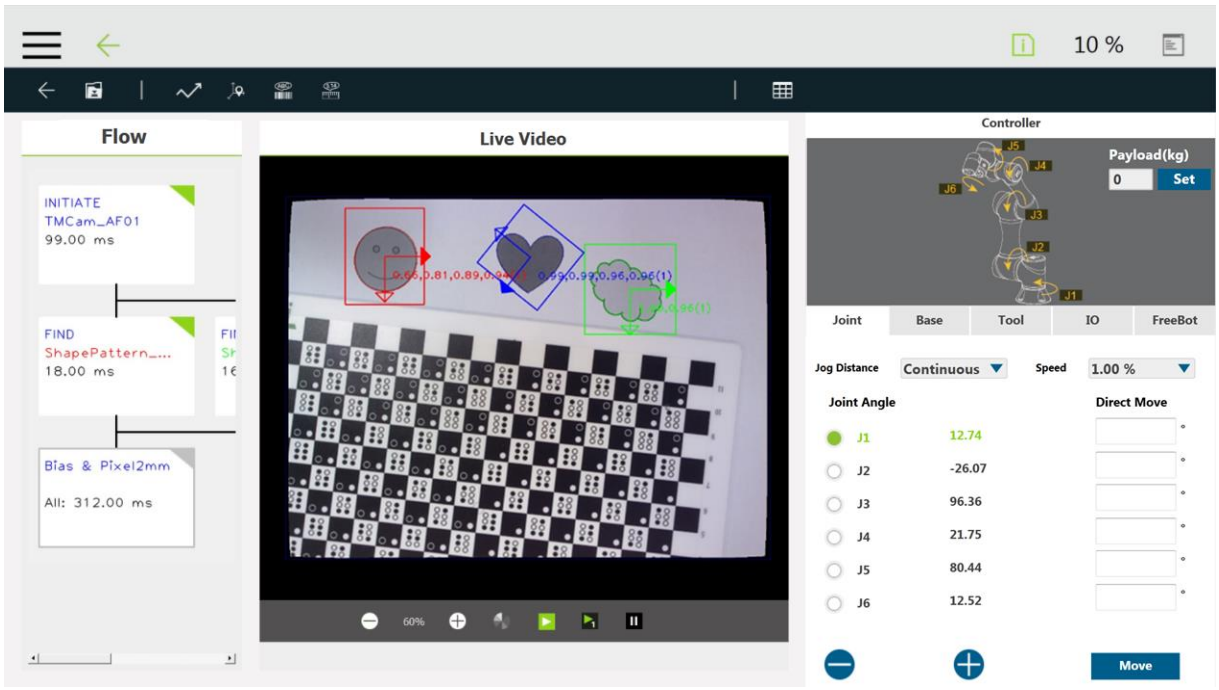
Step 2: Click INITIATE, add another object search module process, and the "How do you add this Process to the Flow?" page will appear. Click Parallel to add more independent processes. You may create a new object search module for each process without impact on the other ones. Click Cascade and a default process displays.





Step 3: Saving job

NOTE: Vision jobs can be saved subject to the conditions of "Object is detectable and only ONE object is detected", i.e. only one of the objects shall be and can be found.



3.3.3 Identification

The identification module provides two basic functions: Barcode and color identification with string output once successfully identified. Users may compile processes in TMflow with output of results.

Function module	Function description	Output (floating point)
Barcode / QR code 	Read the barcode, the 2D DataMatrix, or the QR code.	Failure in retrieving or executing string or barcode readings shall result in output “” (empty string).
Color classifier 	Color classifier	The user sets the characters for the string and for the training.

3.3.3.1 Barcode / QR Code

This module supports the decoding of 1-D barcode, QR code and 2-D DataMatrix. The user frame selects the barcode region in the Set Barcode Range for the identification. Regarding barcodes in white symbols on black background: You may select "Enhance" (and set Alpha value to -1) to invert the image before identifying it.

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

Barcode / QR code 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

2D Barcode Type	Minimum block size (pixel)
QR code	4 x 4
Data Matrix	6 x 6

3.3.3.2 Color Classifier

This module 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. 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.

4. TM External Camera

4.1 Overview

TM external camera is the TMvision's licensed software module and can support connections to two external cameras. User can use external cameras as the scenario requires. TMvision also provides support tool to help users adjust the external camera's various parameters. Except for servoing, the external camera can be used for all TMvision functions. 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	Remark
BASLER	acA2500-14gc(Color)	GigE (14 fps at 5 MP)	
	acA2500-14gm(Mono)	GigE (14 fps at 5 MP)	

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: 192.168.61.101/192.168.88.102

subnet mask: 255.255.255.0

Default gateway: 0.0.0.0

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 4.5 Calibrating the External Camera, the external camera function will be activated.

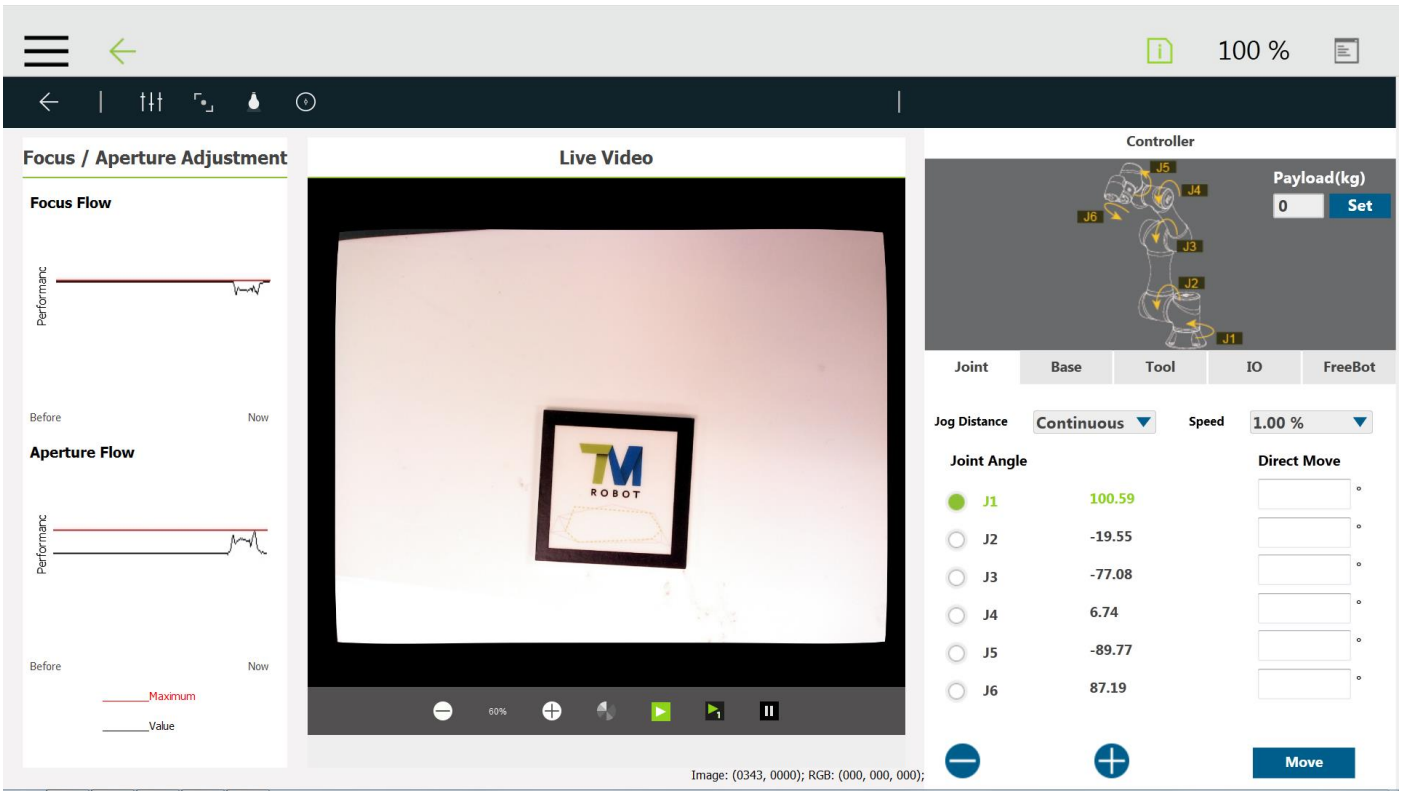
REMINDER:
Make certain the camera is connected to an electric control box's network outlet and make certain that the signal light is on.

4.4 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.

4.4.1 Focus / Aperture

The camera kit provides focus and aperture adjustment functions. This can help users adjust externally connectedindustrial 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 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.



4.5 Calibrating the External Camera

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

4.5.1 ETH Camera Calibration

Automatic Calibration:

Step 1: To establish a new vision job, select the "Unknown" external camera on the left side camera list. Then select calibrate camera. When the menu appears, select "Eye-to-Hand" and then choose automatic calibration.

Step 2: Calibrate the eye-to-hand camera's internal parameters. Move the calibration plate to a range that the camera can identify. Click "Next Step" and repeat this step 15 times (each time the calibration plate position and the angle must be different). After completion, click "Next Step".

Step 3: Click Next Step to build a workspace.

Step 4: Calibrate workspace. Move the eye-in-hand camera to within the visual range of the calibration plate. Calibrate the eye-in-hand and eye-to-hand camera's external parameters and corresponding relationship. Click "Next Step" after completion.

Step 5: Save calibration result.

Manual Calibration:

Step 1: To establish a new vision job, select the "Unknown" external camera on the left side camera list. Then select calibrate camera. When the menu appears, select "Eye-to-Hand" and choose manual calibration.

Step 2: Calibrate the eye-to-hand camera's internal parameters. Move the calibration plate to a range that the camera can identify. Click "Next Step" and repeat this step 15 times (each time the calibration plate position and the angle must be different). After completion, click "Next Step".

Step 3: Click "Next Step" to establish workspace.

Step 4: Set and select the tool center of the Calibration Set. Click "Next Step" after completion.

Step 5: Calibrate the eye-in-hand and eye-to-hand camera's external parameters and corresponding relationship. A red dot will appear at the top of the calibration plate screen. Use the tool center to point to the calibration plate's red dot. Repeat this step and select "Next Step" to complete the calibration.

Step 6: Save calibration result.

4.5.2 Upward-looking Camera Calibration

Automatic Calibration:

Step 1: To establish a new vision job, select the "Unknown" external camera on the left side camera list. Then select calibrate camera. When the menu appears, select "Upward-looking" and choose automatic calibration.

Step 2: Fix the calibration plate to the end of the arm. Choose the tool center and set the initial position. Click "Next Step" after completion.

Step 3: Calibrate the upward-looking camera's internal parameters. Click "Next Step" after completion.

Step 4: Calibrate workspace. Click "Next Step" after completion.

Step 5: Save calibration result.

Manual Calibration:

Step 1: To establish a new vision job, select the "Unknown" external camera on the left side camera list. Then select calibrate camera. When the menu appears, select "Upward-looking" and choose manual calibration.

Step 2: Calibrate the upward-looking camera's internal parameters. Fix the calibration plate to the end of the arm and move the calibration plate to a range identifiable to the camera. Click "Next Step" and repeat this step 15 times (each time the calibration plate position and the angle must be different). After completion, click "Next Step".

Step 3: Move the calibration plate to a height appropriate for identifying the object. Click "Next Step" after completion. Start automatically setting of the workspace.

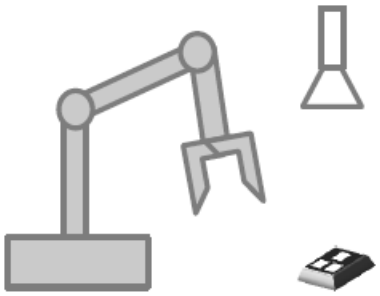
Step 4: Calibrate workspace. Click "Next Step" after completion.

Step 5: Save calibration result.

REMINDER:
Before using manual calibration, use the calibration set to calibrate the appropriate tool center. Make sure that the result error is less than 0.3mm. Then use the calibration set to click the intersection at the top of the calibration plate.

4.6 Eye-to-Hand

TMvision can not only integrate internal vision, but can also match the supporting external camera and feedback obtained information to the robot. This operation allows the robot operation to synchronize with camera shooting and decreases the flow cycle. The following is an illustration of the eye-to-hand camera setting.



4.6.1 Pick'n Place

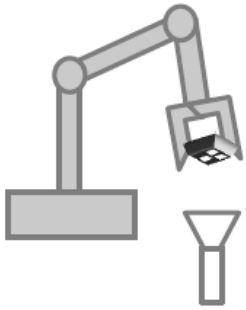
Pick'n Place is the fixed position application for the eye-to-hand function. This function uses the establishment of a workspace so that the robot can use the absolute coordinates to calculate and position objects. Its precision is determined by the calibration accuracy of the workspace. For details on fixed positioning and building a workspace, see sections 3.2.2 Fixed Positioning and 2.2 Vision Base System Positioning Mode. In addition to this, 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-only / Vision-as-IO

The eye-to-hand module supports the AOI-only with Vision-as-IO function. For details, reference section 3.2.3 AOI-only and section 3.2.4 Vision-as-IO.

4.7 Upward-Looking

The TMvision upward-looking function uses the relationship between the base and the arm 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-only and Vision-as-IO function. The following is an illustration of the upward-looking camera's setting.



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 set of vision tool center. This function compensates the workpiece's X and Y-axis coordinates' deviation and rotation angles' deviation for each item grab or suction. This means that even if the user caused a workpiece deviation during the pick'n place, the user can still accurately place the workpiece on the right 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 set of vision tool center.

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

4.7.2 AOI-only / Vision-as-IO

The upward-looking module supports the AOI-only and Vision-as-IO function. For details, see section 3.2.3AOI-only and section 3.2.4Vision-as-IO.

REMINDER:
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 arm moves the object, this object is not suitable for alignment compensation and the object grabbing method needs to be improved.

REMINDER:
Set the tool center position before calibration. The closer the tool center position is to the object plane the more accurate it is.

5. TM OCR

5.1 Overview

TM OCR is the TMvision's licensed software module that provides user with a simple operating interface to set OCR jobs. OCR is divided into OCR and numeral. Measurement, identification, and TM OCR function can be used through the menu at the top of the TMvision setting interface. TM OCR supports the eye-in-hand camera and external cameras. If an external camera (eye-to-hand, upward-looking) needs to be matched to conduct OCR identification, then authorization for the external camera is required. For authorization and use of the external camera, see section 4 TM External Camera.

5.2 OCR

5.2.1 Support Content

- OCR function can output the identification result in string format.
- OCR supports 9 common fonts and their bold format (Regular 400, **Bold 700**). The fonts are shown below.

Font	Type
san-serifs	Courier New, Lucida Bright, Times New Roman
non san-serifs	Arial, Verdana, MS Gothic
monospaced font	Consolas, OCR A Extended, OcrB

- OCR supports 94 different characters, including numerals (0~9), English upper case (A~Z), English lower case (a~z), and 32 ASCII symbols (@/: #$&, etc.).
- OCR identification area is a single line. Characters go from left to right in a straight line or a curve. A single line has a maximum of 32 characters.

5.2.2 Parameter Setting Interface

Name	Function description
Image source	Choose image source.
Name	Name the task.
Set OCR Region	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range.
Segmentation	Adjust character segmentation parameters.
Font Selection	Choose the font of the region to be identified.
White text/black background or black text/white background	Choose White text/black background or black text/white background.
Candidate Characters Menu	Output according to the selected character list. Eliminate other similar characters.
Import Font	Import font file to the IPC from a USB.

5.2.2.1 Setting Identification Region

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.

5.2.2.2 Segmentation

Name	Function description
Bounding Rect Width	Character width must be within this range.
Bounding Rect Height	Character height must be within this range.
Min Char Spacing	Characters are combined when character spacing is lower than this value.
Char Fragment Overlap	Characters are combined when the character overlap ratio exceeds this value.
Min Char Aspect Ratio	Character height divided by width. Characters are segmented if it is lower than this value.
Tilt-angle	Angle correction. Turn tilted characters upright.

5.2.2.3 Font Selection

Choose font type. Currently, TMvision provides 4 trained types for users to choose from, Universal (94 characters), Universal_Digit (numeral 0~9), Universal_UpperCase (English upper case A~Z), Universal_LoweCase (English lower case a~z)

5.2.2.4 Candidate Characters Menu

Candidate characters can be set in the candidate character menu. Characters in black indicate candidate characters, characters in grey indicate eliminated characters The identification result does not output eliminated characters. User can use @ (all), $ (numeral), # (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.

5.3 Numeral OCR

5.3.1 Support Content

- Numeral OCR function can output identification result in a numeral format

Font	Type
san-serifs	Courier New, Lucida Bright, Times New Roman
non san-serifs	Arial, Verdana, MS Gothic
monospaced font	Consolas, OCR A Extended, OcrB

- Support Seven-segment-display.
- Supports 12 types of characters, including numeral (0~9) and -. To determine positive and negative numbers and floating points.
- Identification region is a single line. Characters go from left to right in a straight line or a curve. The output numeral range is from -100000~100000 and the precision goes to four numerals after the decimal point.

5.3.2 Parameter Setting Interface

Name	Function description
Image source	Choose image source.
Name	Name the task.
Set OCR Region	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range.
Segmentation	Adjust character segmentation parameters.
Font Selection	Choose the font of the region to be identified.
White text/black background or black text/white background	Choose white text/black background or black text/white background.
Import Font	Import font file to the IPC from a USB.

5.3.2.1 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.

5.3.2.2 Segmentation

Name	Function description
Bounding Rect Width	Character width must be within this range.
Bounding Rect Height	Character height must be within this range.
Min Char Spacing	Characters are combined when character spacing is lower than this value.
Char Fragment Overlap	Characters are combined when the character overlap ratio exceeds this value.
Min Char Aspect Ratio	Character height divided by width. Characters are segmented if it is lower than this value.
Tilt-angle	Angle correction. Turn tilted characters upright.

5.3.2.3 Font Selection

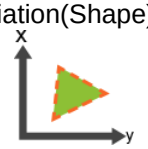
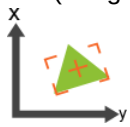
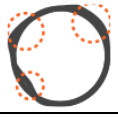
The numeral OCR provides two trained font models for the user to choose from, the Number and seven-segment-display. The Number training font is used with the OCR font and trained with the seven-segment display. The seven-segment-display only uses the seven-segment display font (Digital Counter 7, Ticking Timebomb BB) for training.

6. TM Identify & Measure

TM Identify & Measure is a TMvision licensed software module. In addition to standard "Color classifier" and "Barcode identification", the TM Identify & Measure licensed software module can use the following additional functions, "Pose Variation(Shape)", "Pose Variation(Image)", "Specific Color Area Size", "Subtract Reference Image", "Line Burr", "Circle Burr", "OCR", and measurement module can use the "Pose Variation(Shape)", "Pose Variation(Image)", "Specific Color Area Size", "Subtract Reference Image", "Line Burr", "Circle Burr", "Count(Irregular Objects)", "Count(Shape)", "Count(Image)", "Edge Count", and "Measure Distance and Angle".

6.1 Identification

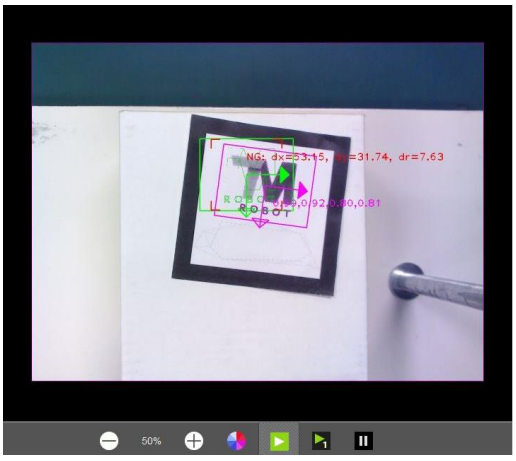
Traditional manual inspection can ential error issues caused by personnel fatigue or negligence. The TMvision identification function can provide comprehensive improvement. The menu at the top of the TMvision setting interface can be used to add the identification function to the vision Flow. The following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

Function module	Output (floating point)
Pose Variation(Shape) 	String. Output TMflow variation "OK" or "NG" according to conditions.
Pose Variation(Image) 	String. Output TMflow variation "OK" or "NG" according to conditions.
Specific Color Area Size 	String. Output TMflow variation "OK" or "NG" according to conditions.
Subtract Reference Image 	String. Output TMflow variation "OK" or "NG" according to conditions.
Line Burr 	String. Output TMflow variation "OK" or "NG" according to conditions.
Circle Burr 	String. Output TMflow variation "OK" or "NG" according to conditions.

6.1.1 Pose Change(Shape)

This module uses the object's shape feature to calculate variation and askewness to determine whether the object's level of pose change is within the decision range. This can be used to inspect whether the label position on the product has changed or is askew.

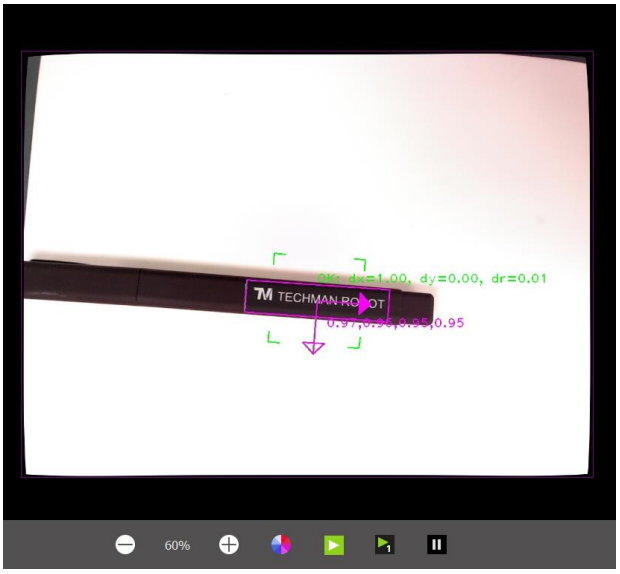
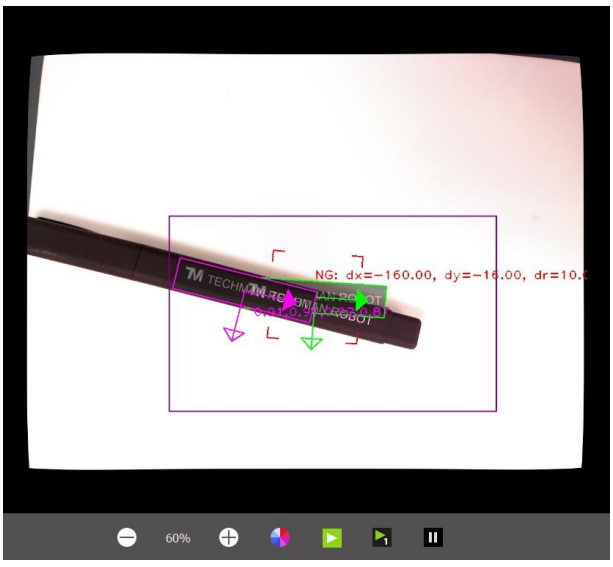
Name	Function description
Image source	Choose image source.
Name	Name the task.
Pattern Selection	After clicking, this image window will pop up. The user can select items from the image.
Edit Pattern	Click and the edit window pops up for you to edit shape feature of the object.
Set search range	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range.
Num. of Pyramid Layers	More layers means that the search time can be significantly reduced. However, if the workpiece has too many details, the details can be easily erased and cause detection errors.
Min. Score	Object can be determined only when the score of the detection result is higher than the minimum setting.
Directional Edge	Select whether the shape edge is directional.
Decision	Pose's X-variation: X-direction's allowable shift deviation. Pose's Y-variation: Y-direction's allowable shift deviation. Pose's angle variation: Angle's allowable rotation deviation.

OK	NG
	

6.1.2 Pose Change(Image)

This module uses the object's image feature to calculate variation and askewness to determine whether the object's level of pose change is within the decision range.

Name	Function description
Image source	Choose image source.
Name	Name the task.
Pattern Selection	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 for you to edit shape feature of the object.
Set search range	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range.
Num. of Pyramid Layers	More layers means that the search time can be significantly reduced. However, if the workpiece has too many details, the details can be easily erased and cause detection errors.
Min. Score	Object can be determined only when the score of the detection result is higher than the minimum setting.
Similarity Metric	The user can use the "Correlation Coefficient" or the "Absolute Difference" to select the most appropriate measuring method. The former is slower, but it can resist environmental lighting and has stronger light and shadow change capability.
Decision	Pose's X-variation: X-direction's allowable shift deviation. Pose's Y-variation: Y-direction's allowable shift deviation. Pose's angle variation: Angle's allowable rotation deviation.

OK	NG
	

6.1.3 Specific Color Area

This module uses the object's color area to determine whether the size of the area is within the decision range.

Name	Function description
Image source	Choose image source.
Name	Name the task.
Select ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Add region to be omitted	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 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.
Decision	Area size: The total colored area in this range determined to be OK.

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

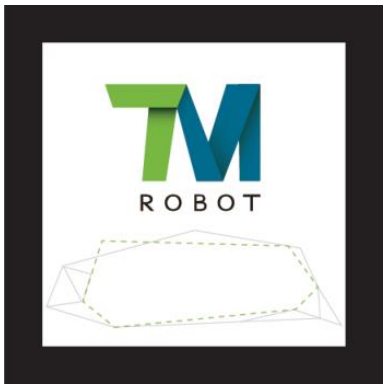
OK	NG
	

6.1.4 Subtract the Template Image

This module uses the difference with the reference image to calculate whether the defect quantity that conforms to the defect range is within the decision range.

Name	Function description
Image source	Choose image source.
Name	Name the task.
Select ROI	After clicking, this image window will pop up. The user can choose the reference image on this image.
Add Region to be Omitted	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 Area Size	Only defect area in this range will be included in the defect quantity.
Decision	Defect quantity: Total defect quantity in this range is determined to be OK.
Bounding Box	Select this function to show the defect position with a bounding box.
Deburring	Remove the image edge or erroneous determination caused by pattern matching.
Element Size	Remove the bur calculation element size.

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

Reference image	Defect image	Detection result image
		

IMPORTANT

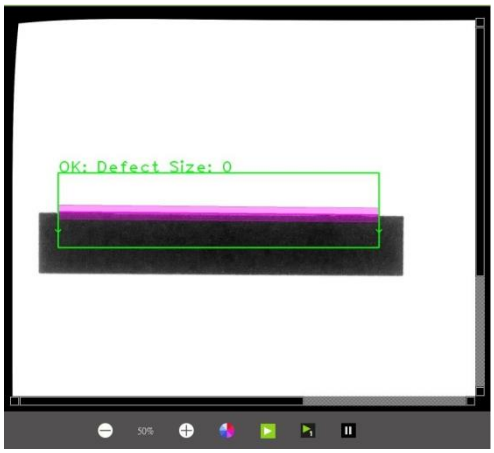
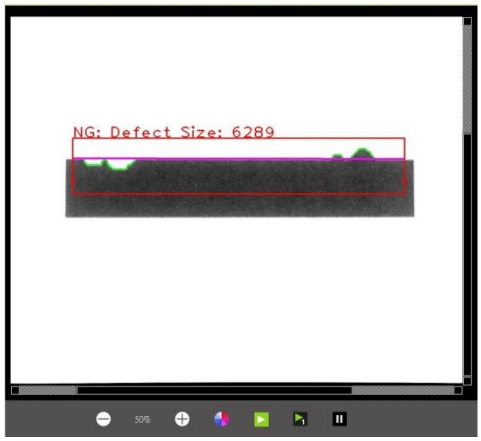
REMINDER:
When the "Find" module caused a position error, the bur on the edge will be erroneously determined as damage. The user can select the deburring function. The larger the element size the greater the calculation range.

6.1.5 Line Burr

This module uses the differences between the detected edge and the ideal straight line distance to calculate whether the total defect area is within the decision range.

Name	Function description
Image source	Choose image source.
Name	Name the task.
Select 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.
Decision	Defect area size: Total defect area in this range is determined to be OK.
Detection Specification	Defect points at most take up 30% of the detected straight line to ensure the stability of the detected straight line.

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

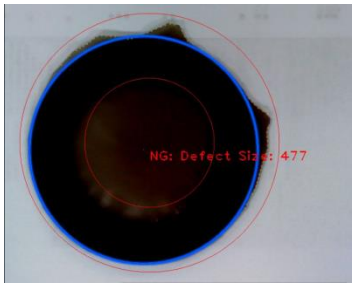
OK	NG
	

6.1.6 Detecting Burrs on Circles

This module uses the differences between the detected edge and the ideal circular radial distance to calculate whether the total defect area is in the decision range.

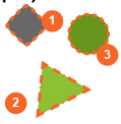
Name	Function description
Image source	Choose image source.
Name	Name the task.
Select ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Intensity Threshold	Only threshold differences greater than this value will be detected.
Detection angle	The 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.
Decision	Defect area size: Total defect area in this range is determined to be OK.
Detection specification	Defect points take up at most 25% of the detected round to ensure the stability of the detected round.

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



6.2 Measuring

The object measurement module is TMvision licensed software. Select the menu at the top of the TMvision setting interface to add the measurement function to the vision Flow. The 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.

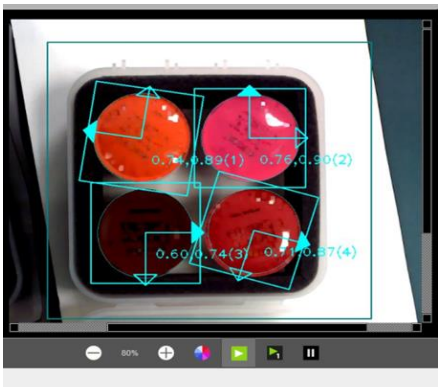
Function module	Output (floating point)
Count(Irregular Object) 	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Count(Shape) 	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Count(Image) 	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.

Edge Count 	Value, object quantity. When the object cannot be found, the output of TMflow variation is 0.
Distance and Angle  Measurement	Value, object quantity. When measurement cannot be done, the output TMflow variation is -1.

6.2.1 Count-Object(Shape)

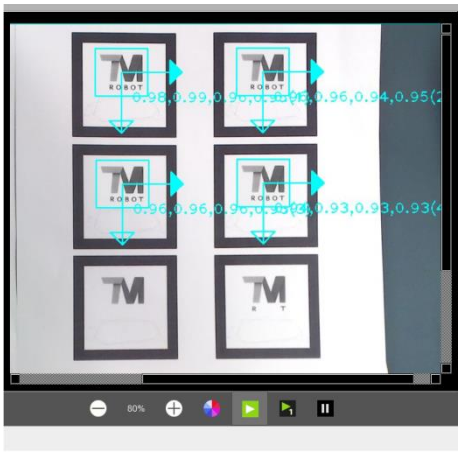
Name	Function description
Image source	Choose image source.
Name	Name the task.
Pattern Selection	After clicking, this image window will pop up. The user can select items from the image.
Edit Pattern	Click and the edit window pops up for you to edit shape feature of the object.
Set search range	After selecting, users can set the position range of the object in the image, to rotate range and shrink/enlarge range.
Num. of Pyramid Layers	More layers means that the search time can be significantly reduced. However, if the workpiece has too many details, the details can be easily erased and cause detection errors.
Min. Score	Object can be determined only when the score of the detection result is higher than the minimum setting.
Directional Edge	Select whether the shape edge is directional.

The following example uses the shape feature to detect product quantity (This example first uses morphology operation to retain the shape of the object in the image. This eliminates the inability to detect the object because of differences in product printing).

Pattern Selection	Identifiable object
	

6.2.2 Count-Object(Image)

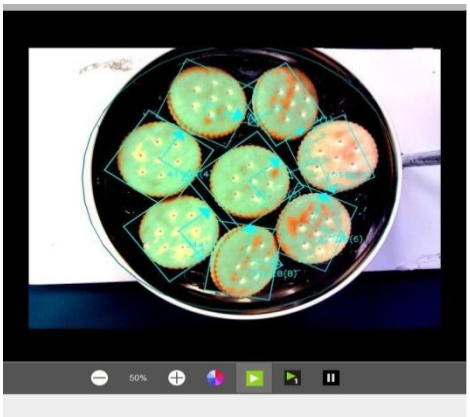
The following example uses the image feature to detect the correct number of printings.



6.2.3 Count-Object(Irregular Object)

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

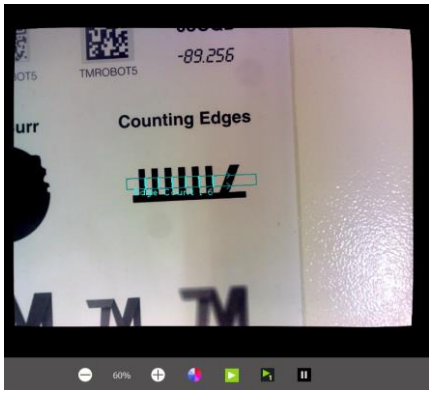
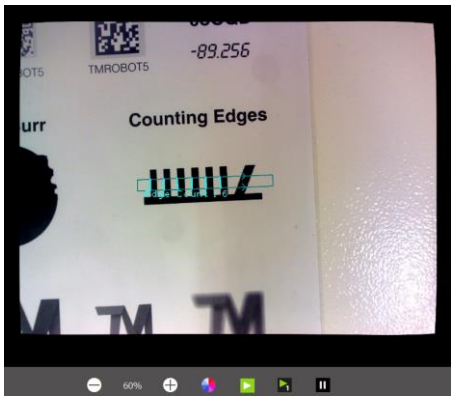
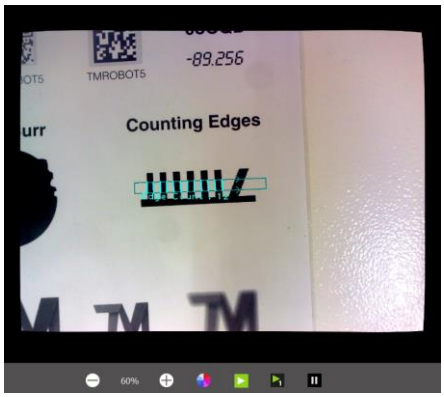
Name	Function description
Image source	Choose image source.
Name	Name the task.
Select ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Add Region to be Omitted	Click to set the region to be omitted. The area within the range will not be added to the decision.
Color Plane	Choose RGB or HSV 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.

Pattern Selection	Identifiable object
	

6.2.4 Count-Object(Edge)

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

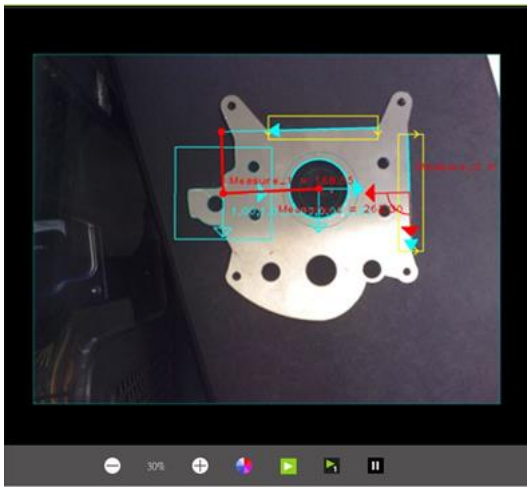
Name	Function description
Image source	Choose image source.
Name	Name the task.
Select ROI	After clicking, this window will pop up. The user can select the region to be detected on the image.
Scan direction	Detect the edge's brightness change direction. After choosing the ROI, the frame will show the 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.

Dark to light	Light to dark	Dual direction
		

6.2.5 Measuring

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 description
Name	Name the task.
Add New Object	Add new measurement elements from the list.
Add New Measure	Choose two elements from the list to measure the distance or angle (only angle can be measured between straight lines).
Unit of Distance	The pixels can be converted to millimeters by the calibration plate or TM Landmark (for reference only).



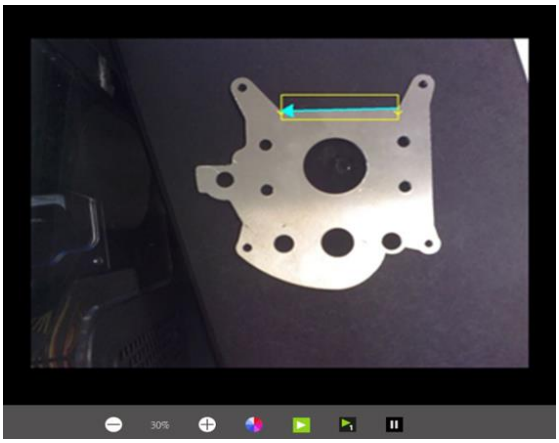
6.2.5.1 Anchor

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 TrackBar to adjust the anchor point placement and angle.

Name	Function description
Image source	Choose image source.
Name	Name the task.
Manual Adjustment	Manually drag the anchor point to the target position.
X direction shift (pixels)	Change the anchor position to the X direction of home point.
Y direction shift (pixels)	Change the anchor position to the Y direction of home point.
Rotation	Change the anchor of home point.

6.2.5.2 Straight Line

Name	Function description
Image source	Choose image source
Name	Name the task
Select 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.

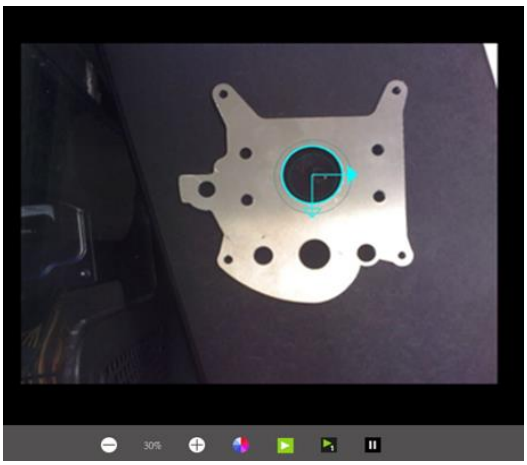


IMPORTANT

REMINDER:
Can only measure the angle between two straight line elements and not the distance.

6.2.5.3 Round

Name	Function description
Image source	Choose image source.
Name	Name the task.
Select 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.
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.



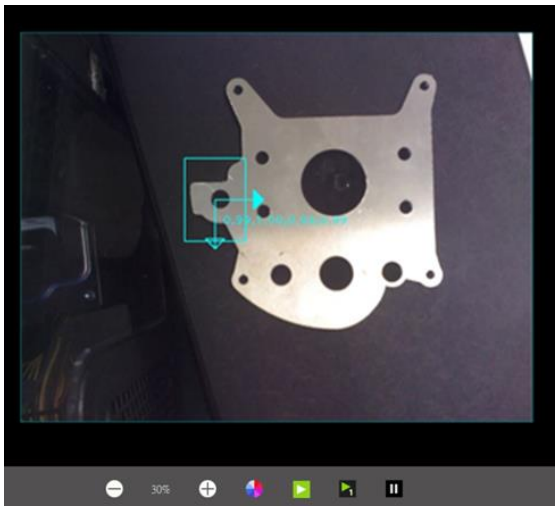
External

6.2.5.4 Object(Shape)

Click "Pattern Selection". Select the shape of the newly added object in the pop-up window. Use Set Pattern to change the object shape and set the range. Adjust the number of Pyramid Layers and the minimum score to stabilize the result.

6.2.5.5 Object(Image)

Click "Pattern Selection". Select the image of the newly added object in the pop-up window to set the search range. Adjust the number of Pyramid Layers and the minimum score to stabilize the result.



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