



SCORPION
VISION SOFTWARE®

GETTING STARTED TUTORIAL

Advanced 2D Training



Goals of this Tutorial

- Understanding the 'TemplateFinder3 and Polygon Match for Object Location' features available in Scorpion Vision Software for Advanced 2D Training.

Before Starting the Tutorial

- Scorpion Vision Software version 8.1 .o.452 or higher needs to be installed on the test machine and valid license.
- To get a valid demo licence go to <http://scorpion.tordivel.no/demolicence.htm>
- An actual camera is not required since you will be using the 'simulator' feature available in Scorpion Vision Software.
- The data files available with this tutorial should be copied to the test machine:
 - (1) 'Advanced2DTraining.zip' which is a preconfigured profile, demonstrating simple approach
 - (2) 'Advanced 2D Training_AdvancedApproach.zip' which is another preconfigured profile, demonstrating advanced approach
- It is recommended to study the 'Getting started tutorials' Part 1 to Part 5 before starting this tutorial.

Advanced 2D Training

The Scorpion Vision Software provides a very easy and powerful way of 2D object location. Using image templates and polygon models objects are located with sub-pixel resolution.

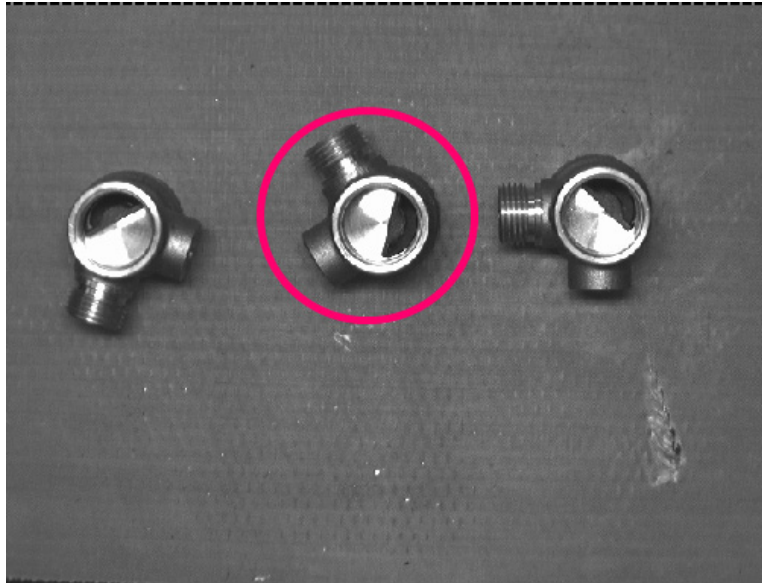


Figure 1: Training

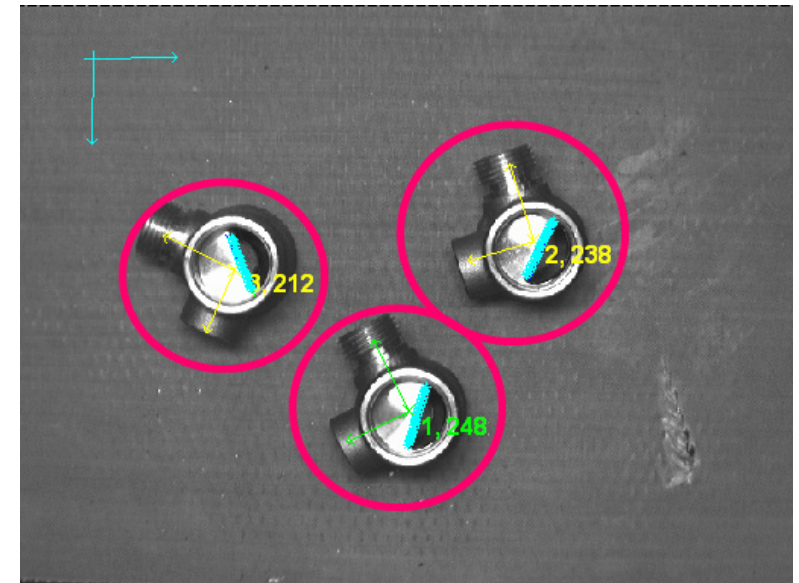


Figure 2: Detection

The main advantage of using templates is that it is easy to teach different objects or patterns. Scorpion Vision Software learns the object as a combination of an image and a polygon model and uses this for object location.

Scorpion Vision Software is able to locate multiple objects with different scale, rotation, and position. Objects can also be partly occluded.

In this tutorial, we will study the 'TemplateFinder3' tool which can be used for 2D training of objects.

The 'TemplateFinder3' tool works in 2 steps.

The first step is 'template matching' where the trained object is remembered in the form of an 'image template'. During inspection, this template is applied on all possible locations in the target image and analyzed for the 'match'. During this analysis, template rotation and/or scaling is also considered, as per user configurations. Every analysis generates a result value between 0-255 which is called a 'match score'. Match score indicates how close the match is to the trained template. 0 means no matching at all and 255 means an exact match.

The second step is 'Polygon matching', which also is part of 'TemplateFinder3' tool configuration. 'Polygon matching' however is not a mandatory step, though it is needed to locate an object with sub-pixel accuracy.

One or more polygons can be defined during training. A polygon as name suggests is an outline of a geometric shape which consists of few points serially connected to each-other.

Sides/edges of the polygon are used for training and matching, and not the area inside the polygon.

For good accuracy, polygons are normally defined on visibly good edges available on the object to be trained.

During inspection, processing is done only on the matched objects or candidates from the 'template matching' phase. Polygons are located inside the results from 'template matching' considering rotation and scaling.

Polygon matching also generates a result value after the processing, which is called as 'match score'. Match score indicates how close the matching is. 0 means no matching at all and 255 means an exact match. The match scores from the 'template matching' result and the 'polygon matching' result are then combined together, as per the configured weights to get final 'match score'. If this final confidence factor is higher than the configured threshold, final result is treated as 'match success'.

The recommended way of configuring the 'TemplateMatcher3' tool is to use 'template matching' with lower thresholds to find as many matches as possible and may be a few false matches. Then using 'polygon matching' to eliminate possible incorrect matches from template matcher and get results accurate to sub-pixel level.

To speed up location it can be recommended to use the partial template feature minimizing the image template and then use a larger polygon model.

'Template matching' works on a complete image or larger part of the image and is computationally expensive. Hence it needs a good amount of processing time. Various techniques are available to lower the processing time and still getting accurate results. Simple configurations are available to apply these techniques in Scorpion.

Training is expected to be an iterative process. Depending on the complexity of objects, configuration parameters need to be fine tuned iteratively. Following are the steps in each iteration – 'Training' configuration -> 'Training' -> 'Matching' configuration -> 'Matching' tests -> Analyzing 'Matching' results. In every step, only few parameters are expected to be adjusted to eliminate inaccuracies in the matching results.

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1. *Preconfigured Profile*

- The Advanced2DTraining.zip available with this tutorial is a preconfigured profile which demonstrates 'TemplateFinder3 and Polygon Match for Object Location'.
- This can be used on any computer to see the 'TemplateFinder3 and Polygon Match for Object Location' in action, without needing any additional changes.
- We will first try this preconfigured profile and see it in action.
- Then later in this tutorial, we will copy the preconfigured profile as a new profile, delete the 'TemplateFinder3' tool from the newly created profile and re-configure it.

2. Trying out the Preconfigured Profile

Launch Scorpion Vision software from 'Start->All Programs->Tordivel Vision Solutions->Scorpion 8->Scorpion 8'

Right click on the application window and select the 'Restore' sub-menu. This will pop up the zip file selection dialog.

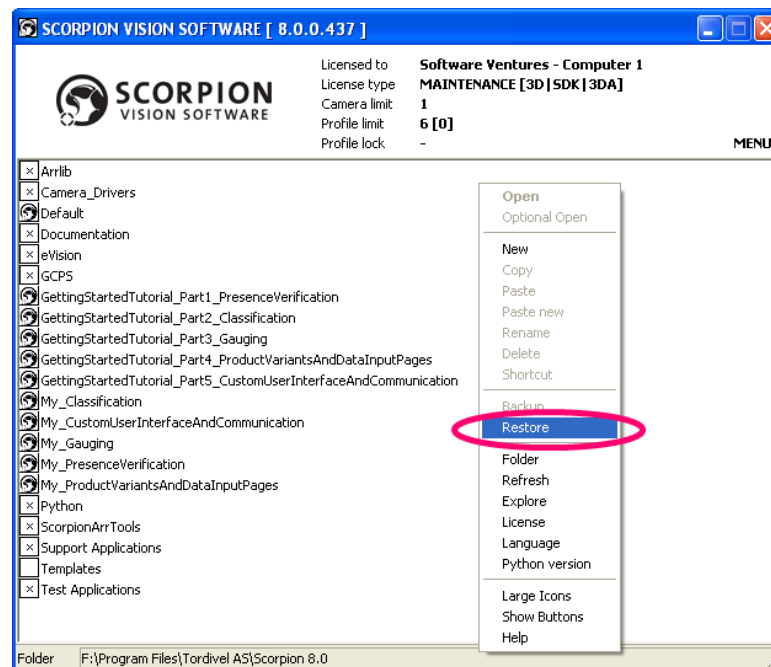


Figure 3: Restore Profile

Navigate to the directory where Advanced2DTraining.zip is available, select it and click on the 'Open' button. Scorpion will restore the profile and it will be added to the available list of profiles.

Right click on the new profile 'Advanced 2D Training' and click on 'Open' sub-menu to launch Scorpion vision software with this profile loaded.

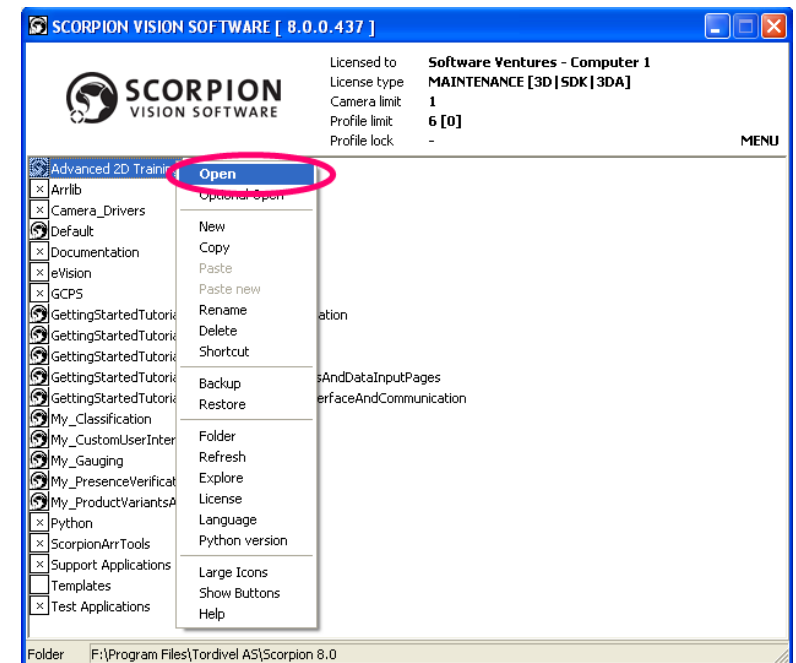


Figure 4: Open Profile

Scorpion has a toolbar available at the top for quick navigation to various commonly used features.

Click on the 'Start' button on the toolbar to start the inspection. Scorpion starts capturing images (from simulator configured in this profile) after every 2 seconds, processes them and generates the results.

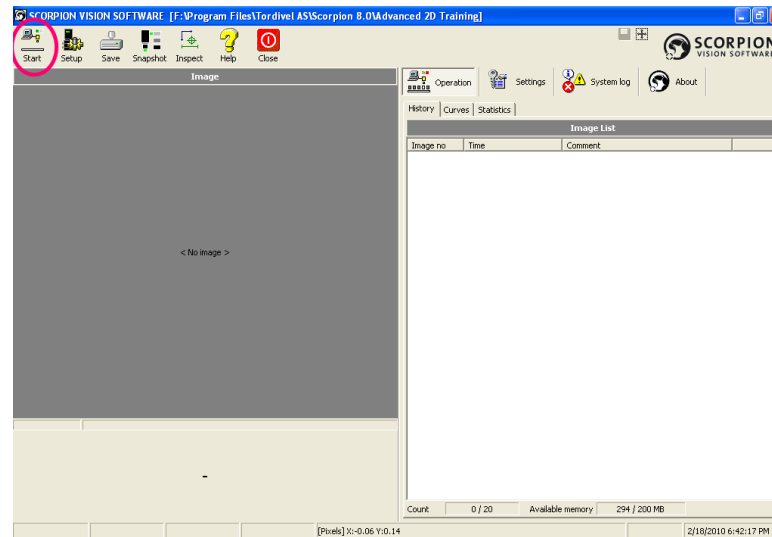


Figure 5: Start the inspection

Scorpion will start detecting the objects (training is already done in the preconfigured profile).

Scorpion analyzes each captured frame and detects whether trained template is available in the captured image.

There are a few frames which have only 1 object in them. Scorpion detects **single match** in these images.

There are a few frames which have multiple objects in them. Scorpion detects **multiple matches** in these images

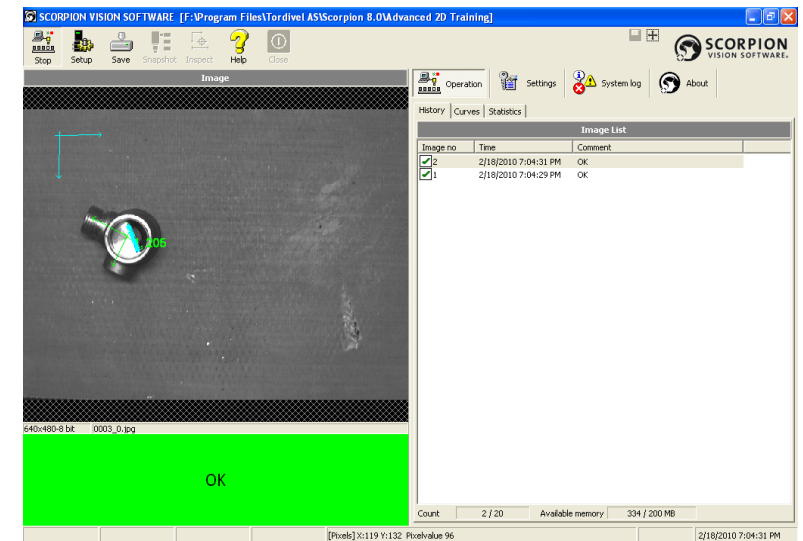


Figure 6: Single Match

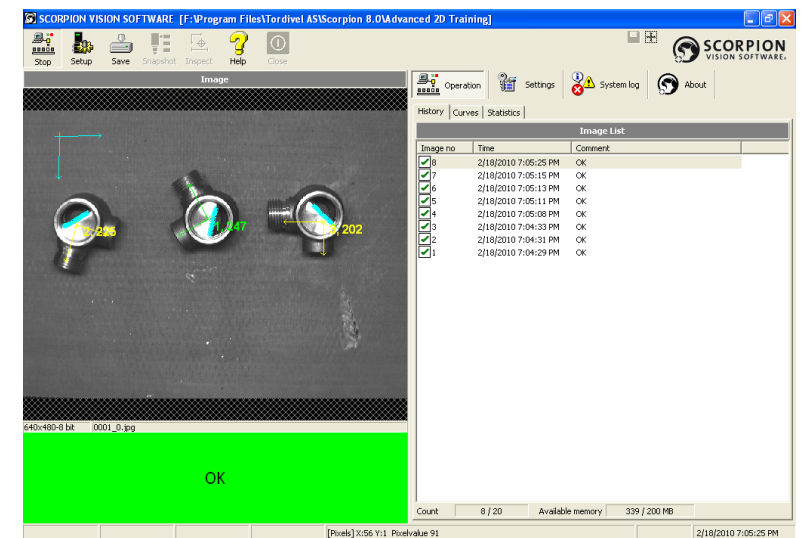


Figure 7: Multiple Matches

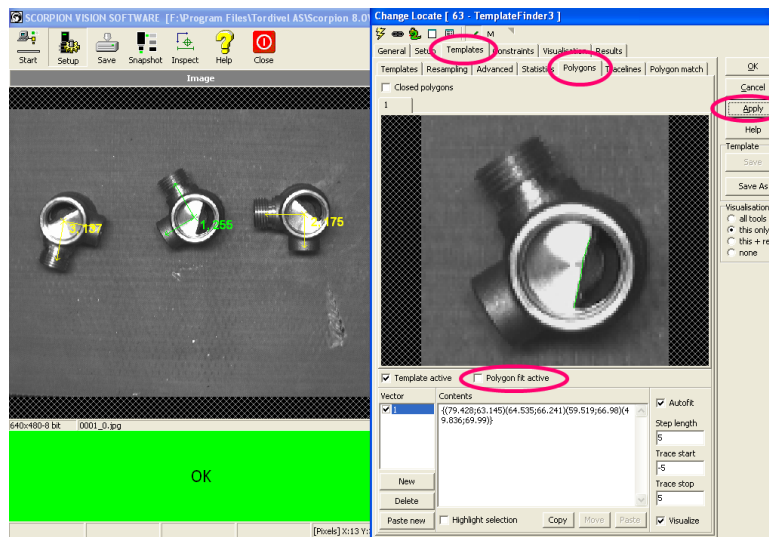


Figure 8: No Match

There are a few frames which do not contain any object. Scorpion does not detect any matches in these images.

The display panel shows important information.

Every detected object has a 'match score' associated with it. This can be between 0-255. Match score is displayed near every matched object.

All matches in an images are sorted by 'match score' and 'result order' is formed. Best match is assigned index '1'. Result order is displayed near every matched object along with match score. Eg '1, 247' indicates result order 1 and match score 247.

There are 2 arrows at right angle drawn on every match. These indicate the **orientation of the match**, as compared to trained template.

For the best match, orientation arrows and other information id displayed in green color and for other matches these are displayed in yellow color.

There is an edge inside the object. The edge is detected and displayed in cyan color.

Click on the 'Stop' toolbar button (previously available 'Start' button is changed to 'Stop' now) to stop the inspection.

Click on the 'Setup' tool bar button. This will pop up the 'Access Control' dialog box. Type password **911** using the keys on the dialog box. Click on the 'OK' button to close the 'Access Control' dialog box.

We have now enabled the 'Service' mode.

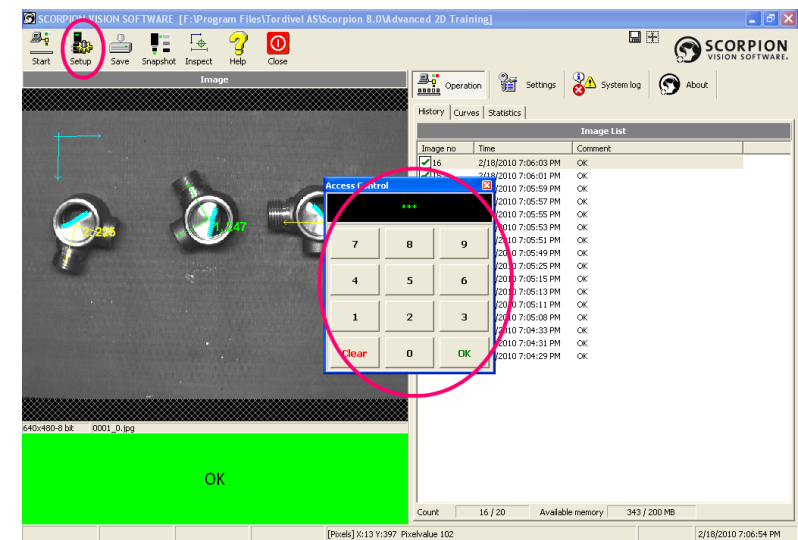


Figure 9: Switch to the 'Service' Mode

Click on the 'Snapshot' toolbar button multiple times till 'ooo1_o.jpg' is displayed in image panel.

Click on the 'Inspect' button to inspect the image and to see the results.

Select the 'Toolbox' tab.

From the available list of tools, select 'TemplateFinder3' type tool named 'Locate'.

Click on the 'Edit' button. This will pop up the 'Change Locate [63 – TemplateFinder3]' dialog box.

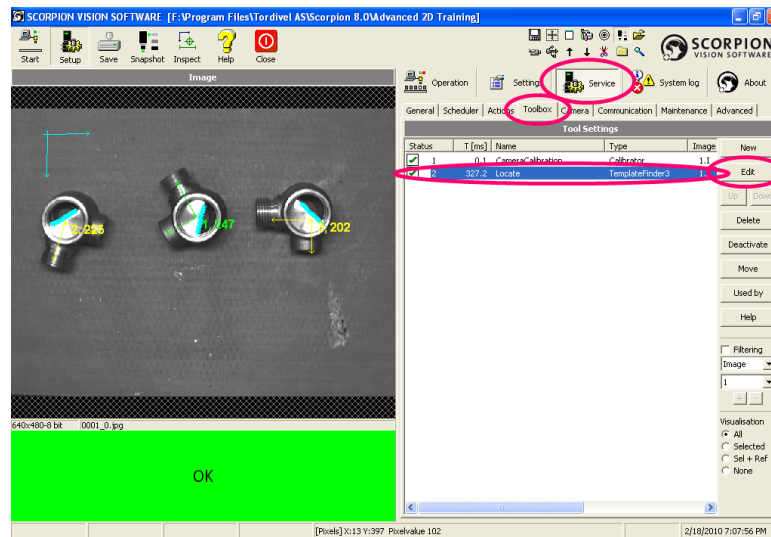


Figure 10: Edit the 'TemplateFinder3' Tool

Select the 'Templates' tab and the 'Polygons' sub-tab.

Uncheck the 'Polygon fit active' check-box, available under the image.

Click on the 'Apply' button to re-inspect the currently captured image with new settings.

The cyan color edge inside every object is not detected now.

Also the 'match scores' change.

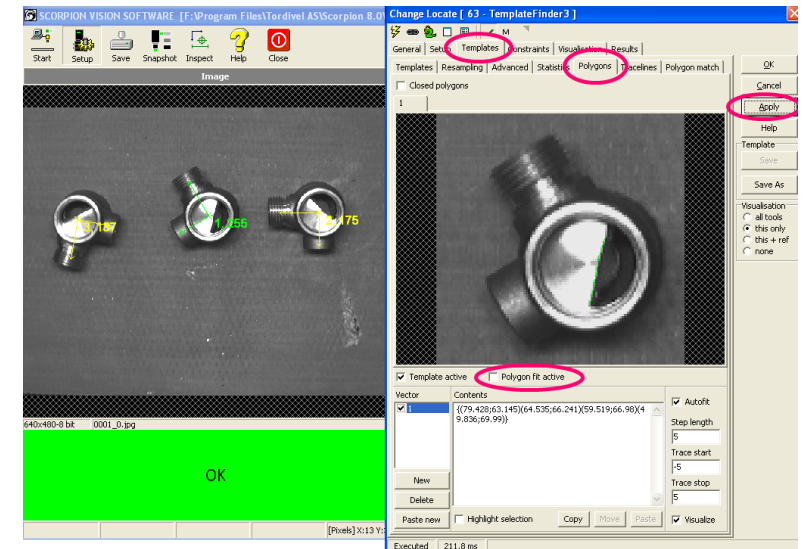


Figure 11: Uncheck 'Polygon fit active'

Select the 'Templates' tab and the 'Advanced' sub-tab.

Uncheck the 'Template modification -> Enable template rotation' check-box.

Click on the 'Apply' button to re-inspect the currently captured image with new settings.

Now there is only 1 result which matches exactly with the trained template. Rotated objects are not detected as matches.

Select 'Templates' tab, to see the trained template,

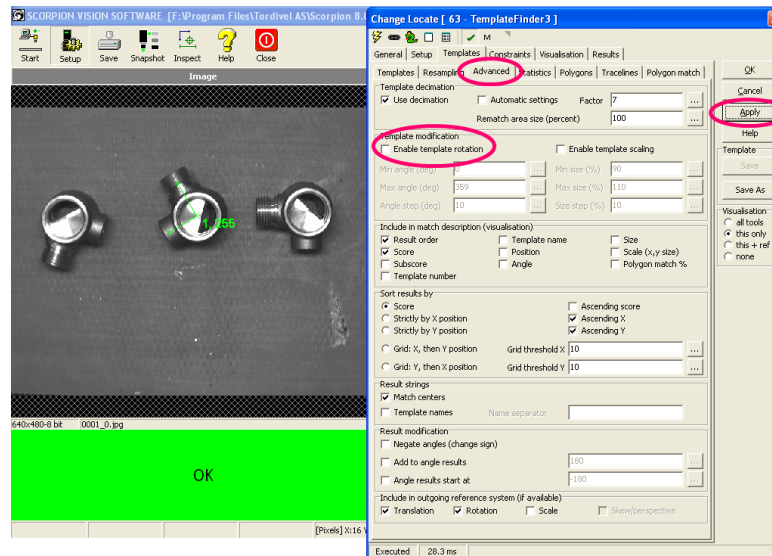


Figure 12: Disable Template Rotation

Select the 'Templates' tab and the 'Polygons' sub-tab.

Check/Enable the 'Polygon fit active' check-box, available under the image..

Select the 'Templates' tab and the 'Advanced' sub-tab.

Check/Enable the 'Template modification -> Enable template rotation' check-box.

This will reset the changes which we have done to the preconfigured profile.

Congratulations!

You have successfully used 'TemplateFinder3 and PolygonMatch' from Scorpion Vision Software for detecting objects as per the trained sample!

Now we are ready to configure 'TemplateFinder3' tool from scratch.

3. Creating a New Profile and Copying Configurations

Close the Scorpion instance which had the preconfigured 'TemplateFinder3 and PolygonMatch for Object Location' profile loaded.

Launch Scorpion Vision Software from 'Start->All Programs->Tordivel Vision Solutions->Scorpion 8->Scorpion 8'.

Right click on the main dialog and click on the 'New' sub-menu. This will ask for a name of the new profile. Type 'My_Advanced2DTraining' (or you may choose any name of your choice) and click on the 'OK' button. This will add the new profile to the list.

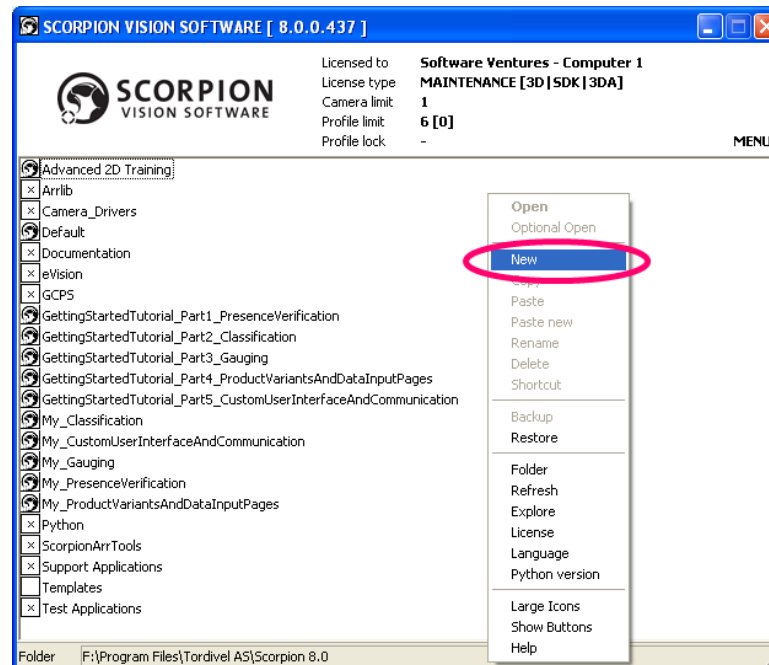


Figure 13: New Profile

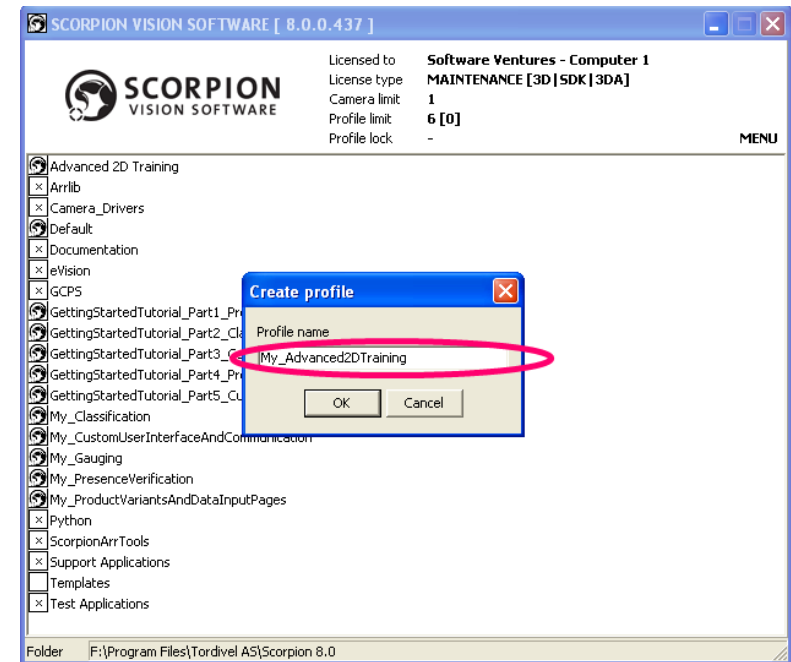


Figure 14: New Profile Name

Right click on the preconfigured profile 'Advanced 2D Training' and click on 'Copy'.

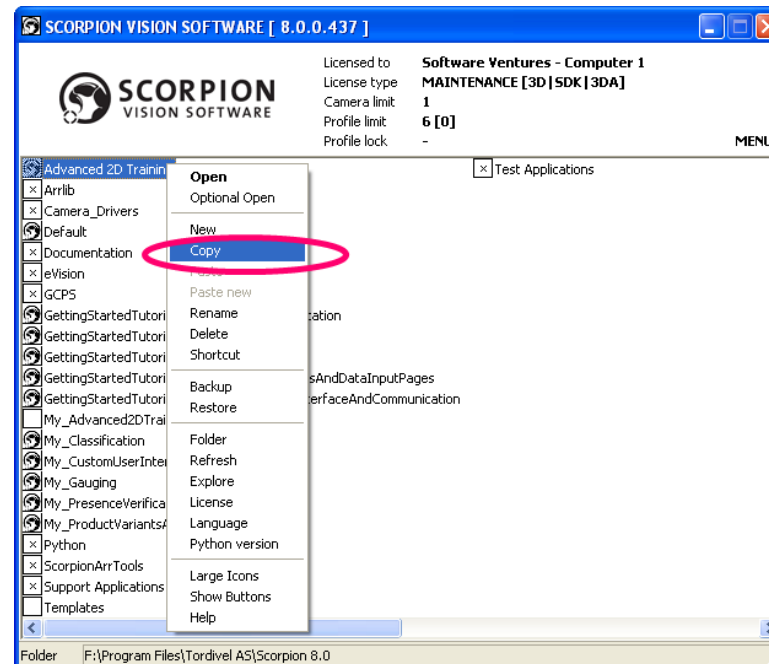


Figure 15: Copy Profile Settings

Right click on the newly created profile 'My_Advanced2DTraining' and click on 'Paste'. Scorpion will pop up a confirmation dialog, click on the 'Yes' button to confirm pasting.

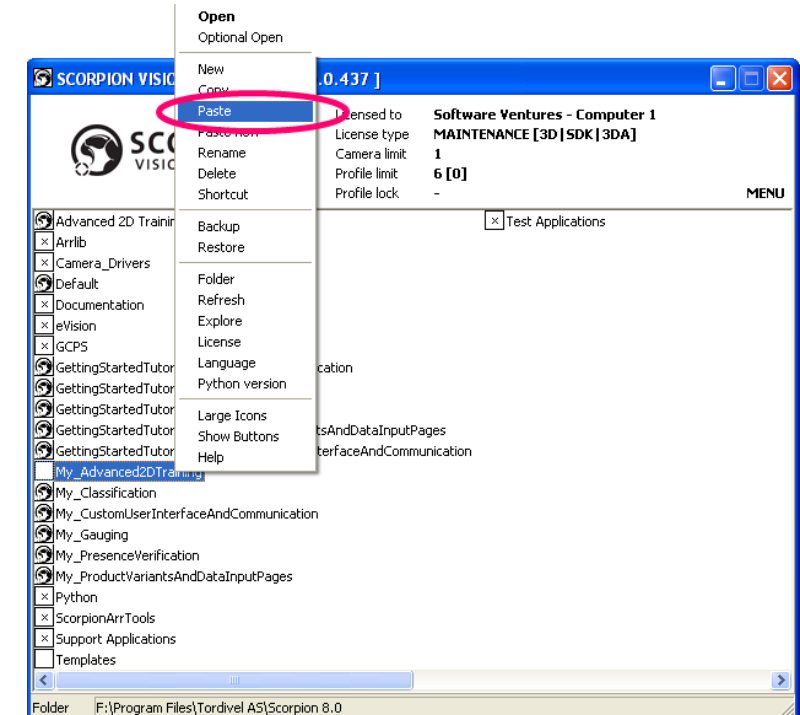


Figure 16: Paste Profile Settings

Right click on the newly created profile name in the list and click on 'Open'. This will also launch Scorpion with the new profile loaded.

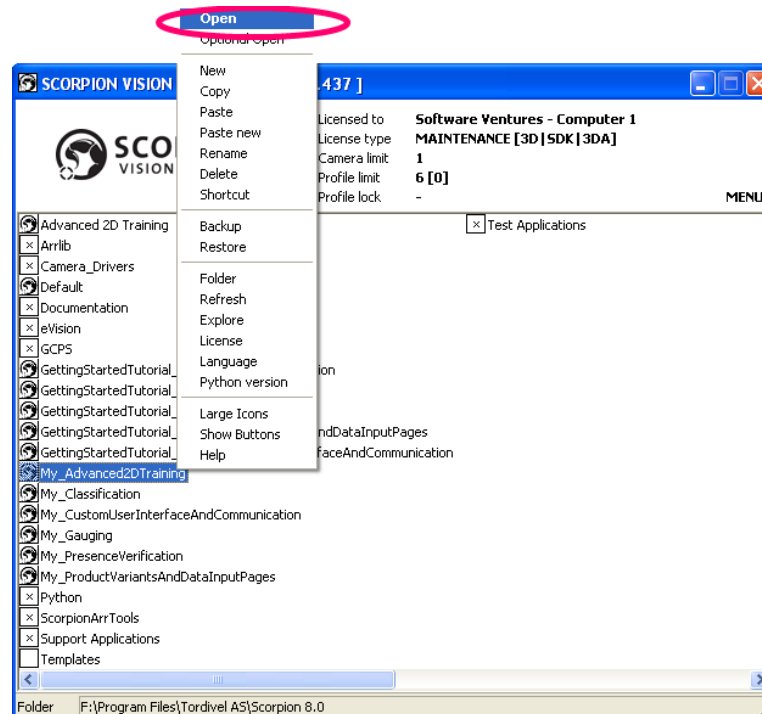


Figure 17: Open Profile

Click on the 'Setup' tool bar button. This will pop up a password dialog. Type 911 and click on the 'OK' button. This will switch Scorpion to 'Service mode'.

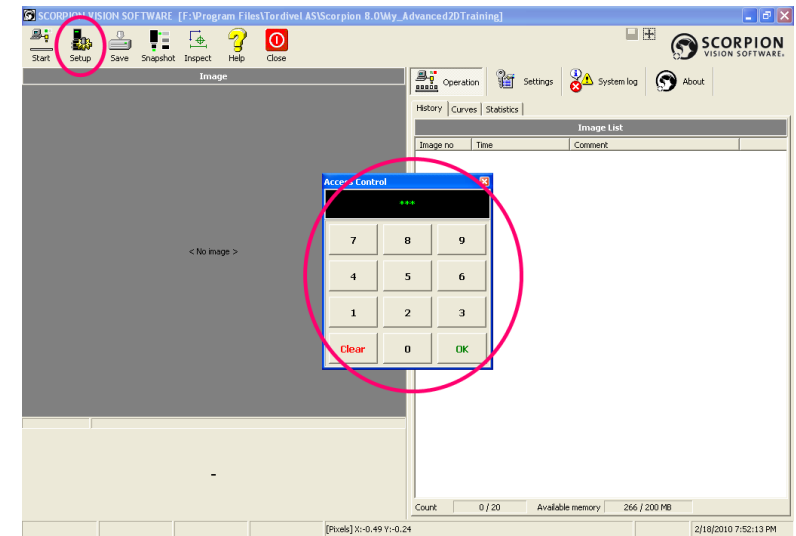


Figure 18: Service Mode Password

Scorpion provides a very easy and convenient way to copy configuration from a profile to another profile. We have used the same to re-use configurations from a preconfigured profile, instead of doing all basic configurations again.

4. Re-configuring 'TemplateFinder3' Tool

Go to 'Service' mode. Click on the 'Toolbox' tab.

From the list of available tools, select tool 'TemplateFinder3', named 'Locate'.

Click on the 'Delete' button.

This will pop up a confirmation dialog box. Click on the 'Yes' button to delete this preconfigured tool.

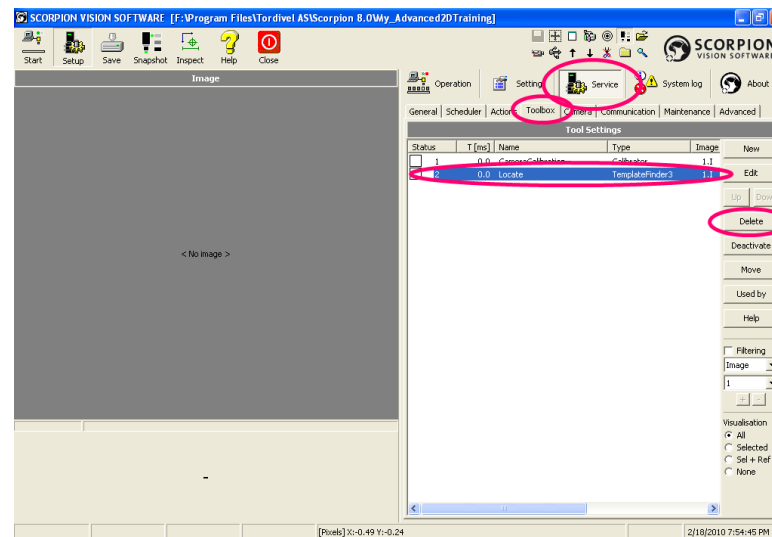


Figure 19: Delete Preconfigured 'TemplateFinder3' Tool

Click on the 'New' button. This will pop up the 'New Tool' dialog box.

Type name as 'Locate'.

Select 'Advanced' category and 'TemplateFinder3' from the list of tools.

Click on the 'OK' button to close the 'New Tool' dialog box.

This will add a new 'TemplateFinder3' type tool to the configured tools list.

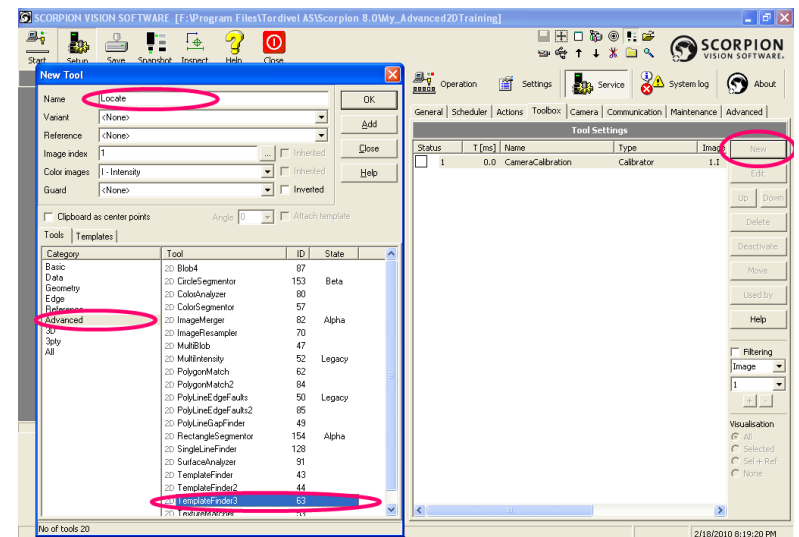


Figure 20: Create New 'TemplateFinder3' Tool

Click on the 'Snapshot' toolbar button. This will capture and show '0001_0.jpg' in Image panel.

Click on the newly added 'TemplateFinder3' type tool and click on the 'Edit' button. This will pop up the 'Change Locate [63 – TemplateFinder3]' dialog box.

Go to the 'Setup' tab.

Select 'Reference' as 'CameraCalibration'.

From 'Search area' group, enable 'Use whole picture'.

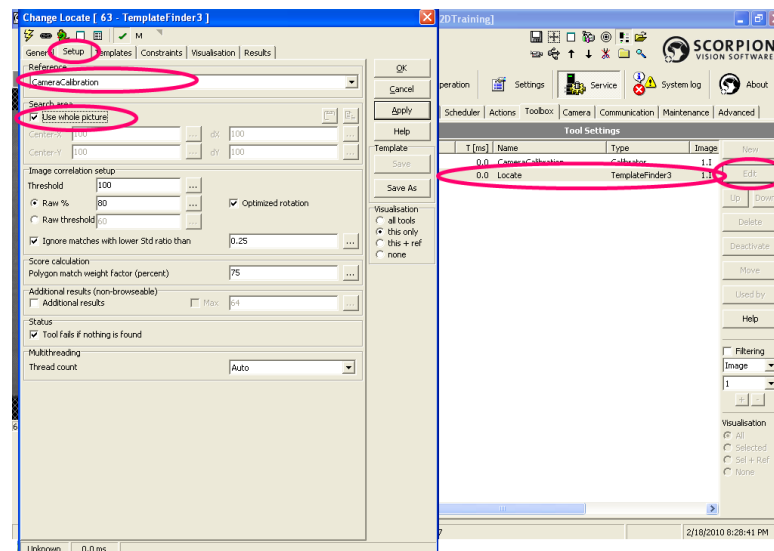


Figure 21: Edit 'TemplateFinder3' Tool.

Go to the 'Templates' tab and 'Resampling' sub-tab.

Select 'Resampled image size -> Resampled image pixel size (approx)' and set the value as 1.5.

Click on the 'Acquire resampled image' button. This will get the currently captured image (which is displayed in image panel on main dialog), re-sample it as per the re-sampling parameter, and will display the re-sampled image.

'Original to resampled pixel ration (apoprox)' will now be displayed as 1.5:1.



Figure 22: Acquire Re-sampled Image

There are 3 objects available in the re-sampled image, we will use the middle one for training (during actual set up, any of the available objects can be used for training)

Click and drag using the mouse to draw a rectangle around the target object. The rectangle will be displayed as mouse is dragged on the re-sampled image.

Mouse button up will zoom into the re-sampled image only to show the zoomed selection rectangle. Zoom indicator icon is also displayed on the left-top corner of the re-sampled image.

Clicking on the re-sampled image will reset zoom and will show the original re-sampled image again.

We will keep the zoomed in view for training.

Click on the 'Copy selection to clipboard' button.

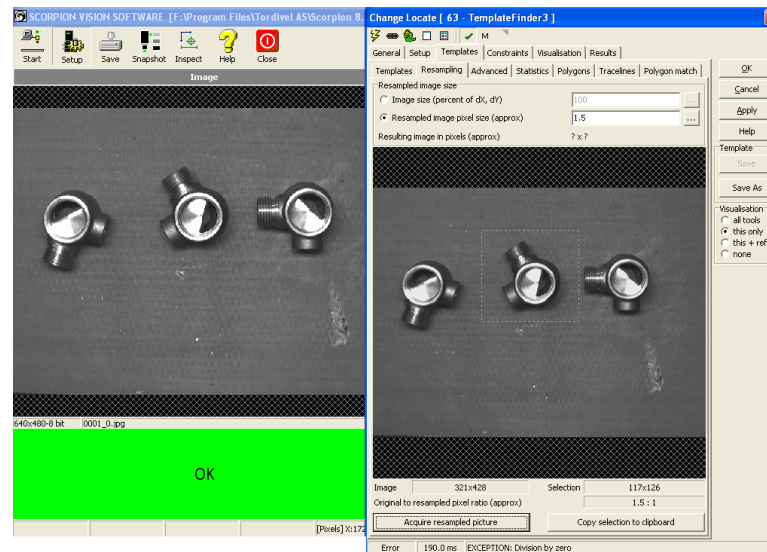


Figure 23: Zoom the Target Object

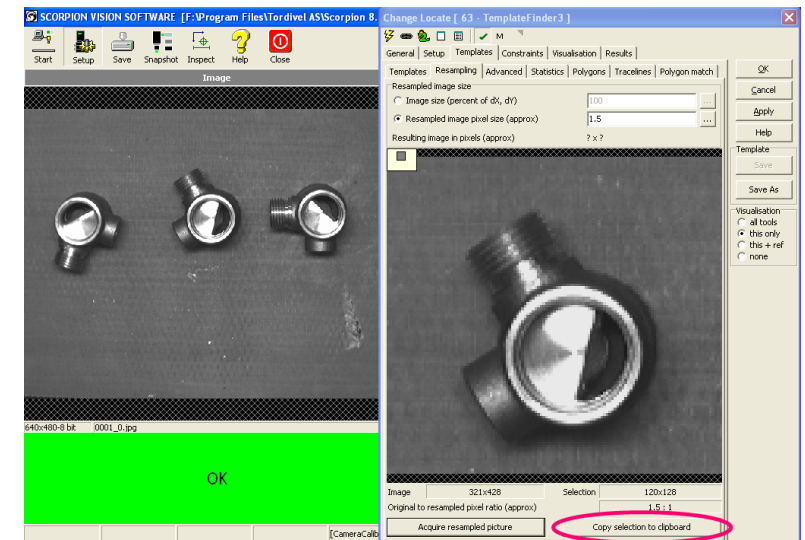


Figure 24: Zoomed Target Object

Go to the 'Templates' sub-tab.

Click on the '+' button to add template image. This is the same zoomed and re-sampled object image we copied to the clipboard recently.

Click on the 'Apply' button to see inspection results on the captured image displayed in the image panel on main dialog. It will show a green rectangle around middle object, indicating a match. Match score is displayed as 255. It's a perfect match since we have used the same object as template for training.

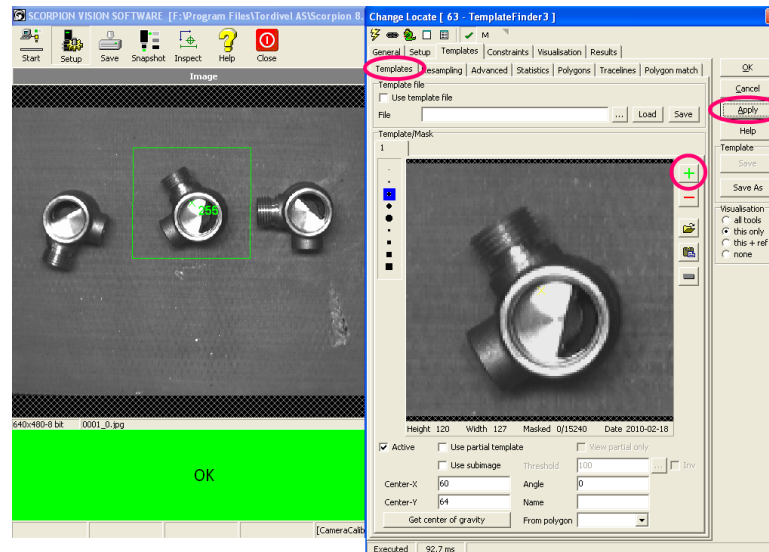


Figure 25: Add Template

Go to the 'Visualization' tab.

Select 'BestDescription', 'BestMatchAxes', 'BestMatchCenter', 'Description', 'Error', 'MatchAxes', 'MatchCenters', 'MatchedPoints', 'Polygon', 'Polygon-Orig' and 'ROI'. De-select all other visualizations.

Click on the 'Apply' button to see the new visualizations updated on the image panel from main dialog.

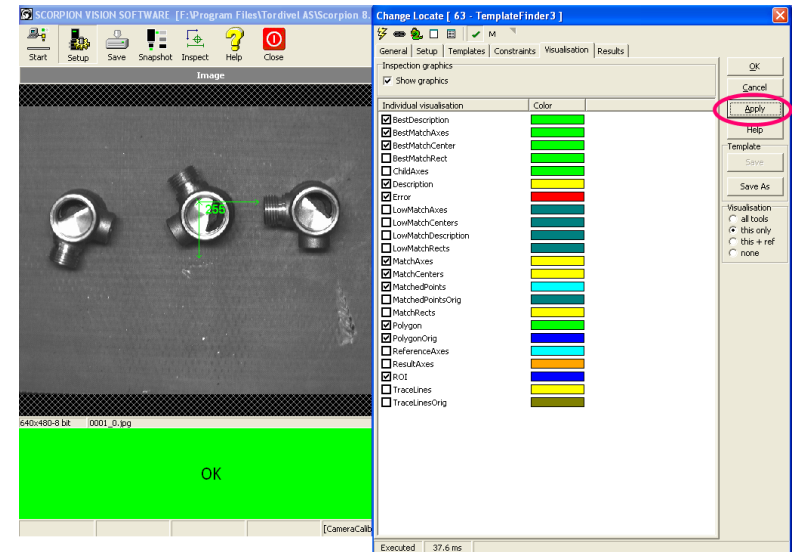


Figure 26: Configure Visualization

Go back to the 'Templates' tab and 'Templates' sub-tab.

Its important to set good reference, which is useful in reviewing the template matching results and making configuration updates easily.

For the current object being trained, **right click** at the center of the circular part of the object and select '**Set center**', to set that point as center of reference. Yellow cross indicating center of reference will move to the newly set center point.

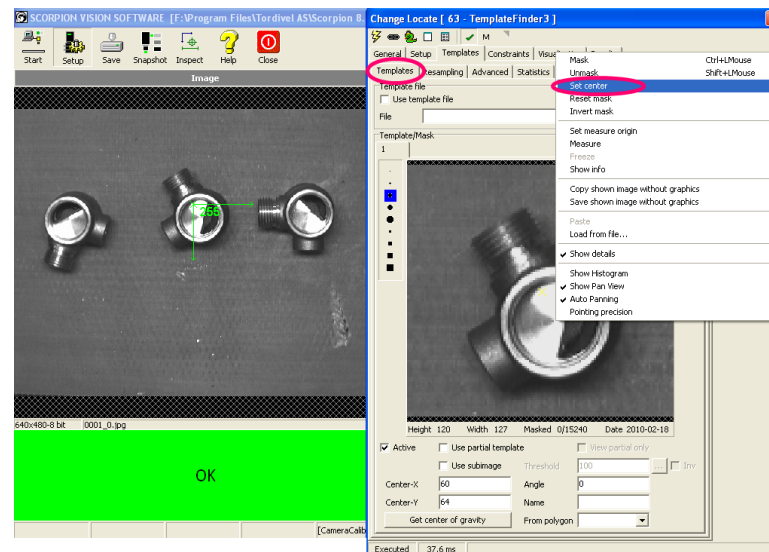


Figure 27: Set Center

Type 'Angle' as 210.

Click on the 'Apply' button to see the results on the currently captured image from image panel on the main dialog.

The axes are now aligned with the 2 protruding parts from the object. This reference can be good visual indication for 'good match'.

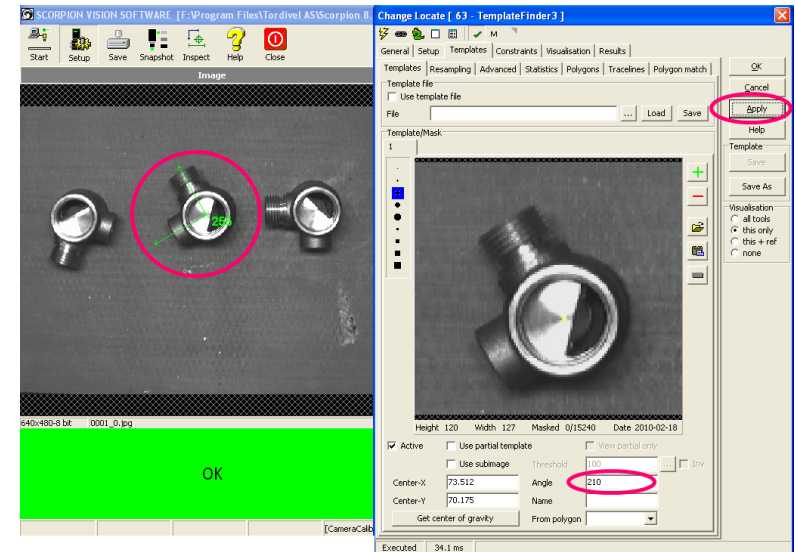


Figure 28: Set Angle

Enable 'Use partial template'. This will draw a green rectangle in dotted lines, on the template image.

This rectangle can be used to eliminate surrounding region and only defining actual object area. The green rectangle can be resized and moved using mouse while ALT keyboard button is pressed.

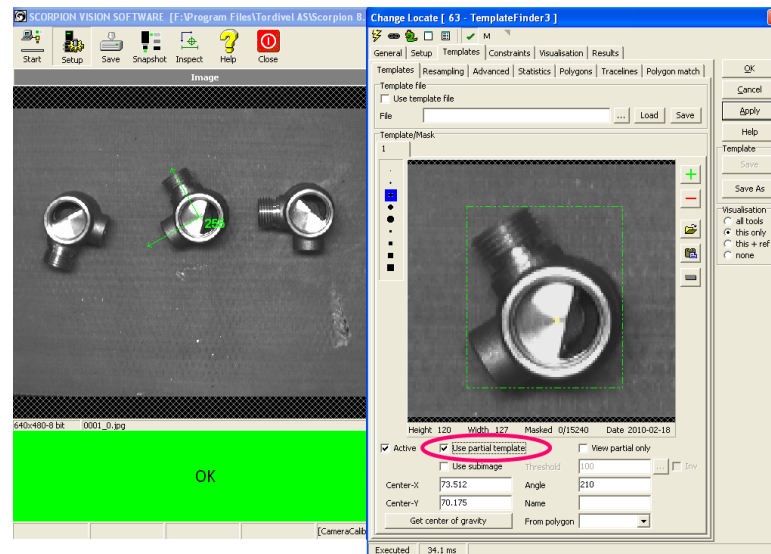


Figure 29: Use Partial Template

Mouse cursor changes to 'move' when its on any of the green rectangle sides and when ALT key is pressed. The green rectangle can be moved by dragging mouse from its sides while ATL key is pressed.

When mouse is at the corners of the green rectangle and ALT key is pressed, cursor changes further to 'cross-hair' indicate 'resizing'. The green rectangle can be resized from its corners by dragging mouse button while ALT key is pressed.

Use rectangle movement and resizing to fit the green rectangle exactly around the object.

Go to the 'Advanced' sub-tab.

Enable 'Template modification -> Enable template rotation'.

Enable 'Include in match description (visualization) -> Result order'.

Click on the 'Apply' button to see the effect of updated configuration on the currently captured image from image panel on main dialog.

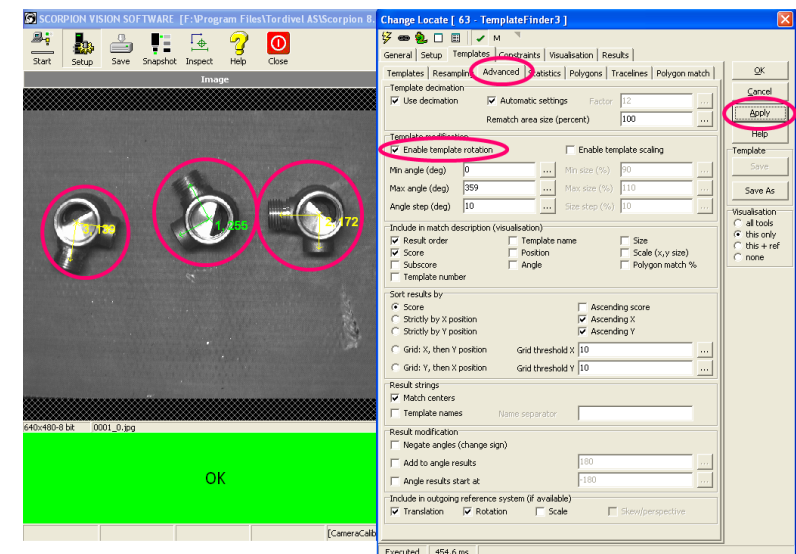


Figure 30: Advanced Settings

All 3 objects are now matched, since we have also enabled template rotation. Result order is also displayed near the matched objects along with the match score.

Reference axes and center point may not be accurate for all matched, and may be slightly offset. This is acceptable and happens since scaling is used and the angle step used during template rotation is 10 degrees (which is the default).

Click on the 'OK' button to close the 'Change Locate [63 – TemplateFinder3]' dialog box.

Click on the 'Start' toolbar button to start the inspection.

Confirm that all objects from all captured images are detected and displayed as matches.

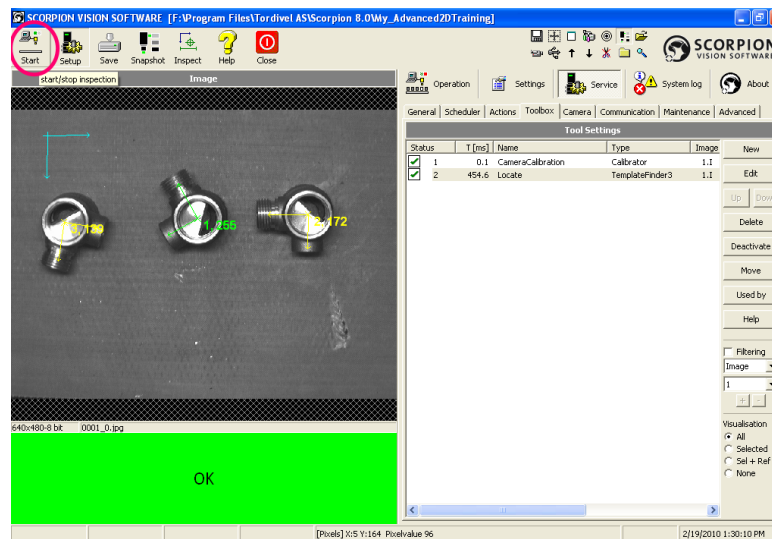


Figure 31: Inspection Test

We have now configured 'TemplateFinder3' tool for template matching.

The 'Calibrator' tool was already available and we are re-using it. Please refer to the Getting Started Tutorial Part1 – Presence Verification for details about Calibrator tool and its setup.

We set the 'Calibrator' tool as 'reference' for the 'TemplateFinder3' tool being configured currently.

We also set the detection region to 'whole picture' since the object can be anywhere in the picture. However if we expect object only in certain region of the picture, it is recommended to define that region as detection region instead of whole picture. This will reduce the processing time for detection.

We then acquired a re-sampled image. The re-sampled image is created from the original image (displayed in image panel from main dialog). The re-sampled image has calibration applied and hence possible lens distortions and camera perspective effect is eliminated in the re-sampled image. This helps in generating good template for training and results in improved accuracy. Re-sampled image is also a scaled down image and has lesser number of pixels than original image. This helps in lowering processing time needed for detection as processing now happens on lesser number of pixels.

If the scaling in re-sampled image needs to be changed, please change the settings and also click on 'Acquire re-sampled image' again to re-sample the original image. The 'Original to resampled pixel ration (approx)' info also gets updated.

We then zoomed the re-sampled image to only see single object, which we plan to use for training. This zoomed image is copied to clipboard and added as a 'template'.

We then set the orientation – center and axes for the template, and we also set various visualizations. These are useful in quick tests and visual confirmations to understand whether training is correct or whether it needs fine tuning. Some of these visualizations - 'MatchedPoints', 'Polygon', 'PolygonOrig', are related to Polygon matching and will be in effect when we configure polygon matching in the next section.

Then we enabled 'use partial match'. In which complete image from the template is not used for matching, but only user defined rectangle is used for matching. We adjusted the rectangle to fit the object exactly in it. It is recommended to include all pixels related to the object, in this partial match rectangle and avoid non-object pixels, as much as possible. This increases matching accuracy and also lowers the processing time.

We finally enabled 'template rotation', so that the template is rotated during matching and can also match the rotated objects. There are settings to control 'template rotation' by angle span of rotation and rotation step. For this tutorial, we want to match complete 360 degrees and we are fine with default 10 degrees rotation step as it is expected to detect all the expected matches with the se settings.

'TemplateFinder3' also has 'template scaling' feature, similar to 'template rotation'. We are not enabling it in this tutorial since we do not expect objects with the same geometry but different sizes (scaled objects).

It may happen that sometimes during inspection tests for template matching, all objects are not detected and displayed as 'matches'. Try reducing 'rotation step', in this case. Also try less scaling during the image 're-sampling' operation. If all objects from all frames are not matched, even after these settings, please use different object for template training and re-do the training.

5. Configuration for Polygon Matching

Click on the **'Stop'** toolbar button to stop inspection, if the inspection is going on.

Go to the 'Toolbox' tab.

From the list of configured tools, select the 'TemplateFinder3' type tool named 'Locate'.

Click on the **'Edit'** button. This will pop up the **'Change Locate [63 – TemplateFinder3]'** dialog box.

Go to the 'Templates' tab and 'Polygons' sub-tab.

The object has a circular part and an edge inside it. We will train this edge as a polygon.

Enable **'Autofit'** and enable **'Visualize'**.

Press CTRL key on the board. While CTRL key is pressed, click on the down-most point on the edge and go on clicking on the edge, moving up till we reach to the other end of the edge.

This will show arrows from the dark region towards the light region, across the edge.

The points also get re-adjusted, since we have enabled Autofit.

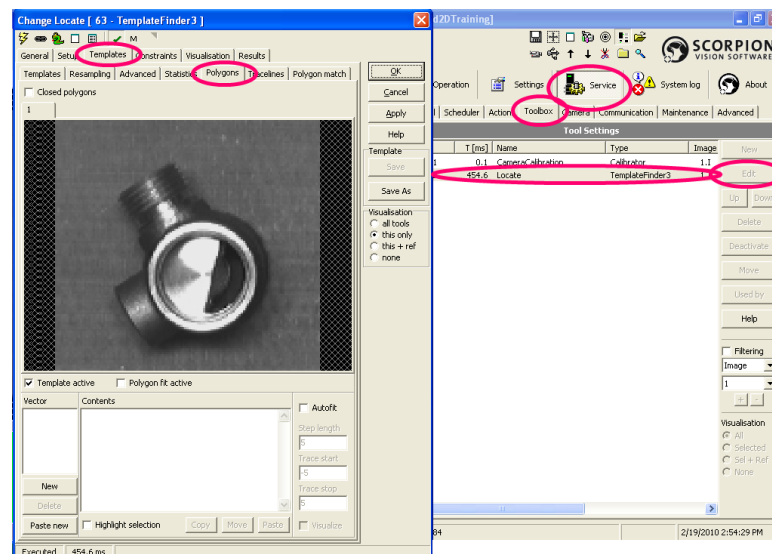


Figure 32: Edit 'TemplateFinder3'

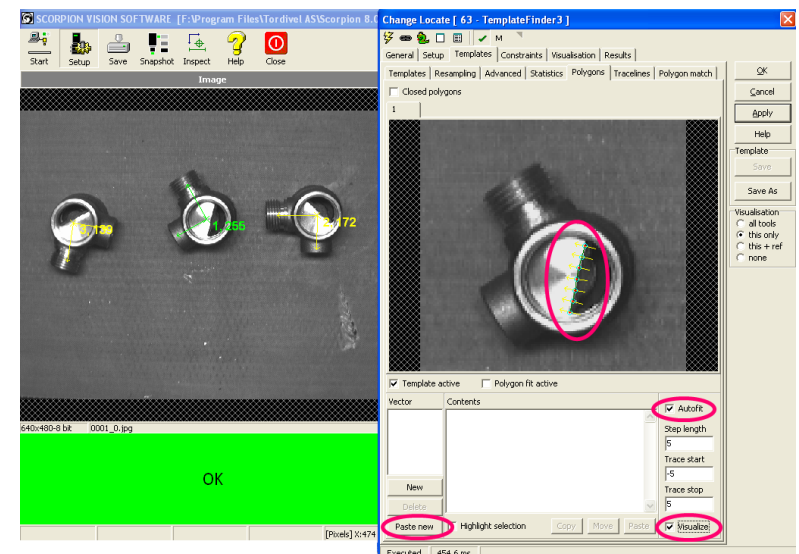


Figure 33: Define Polygon

Click on the **'Paste New'** button. This will add a new polygon vector '1' to the list and include all selected points in it.

Enable on the **'Polygon fit active'** checkbox to enable polygon matching.

Click on **'Apply'** button to see polygon matching in action on the image from image panel on main dialog. Corresponding edges in the objects are matched and highlighted in cyan color.

Click on the **'OK'** button to close the **'Change Locate [63 – TemplateFinder3]'** dialog box.

Click on the **'Start'** tool bar button to start the inspection, to confirm that polygon match works fine on all objects from all captured images.

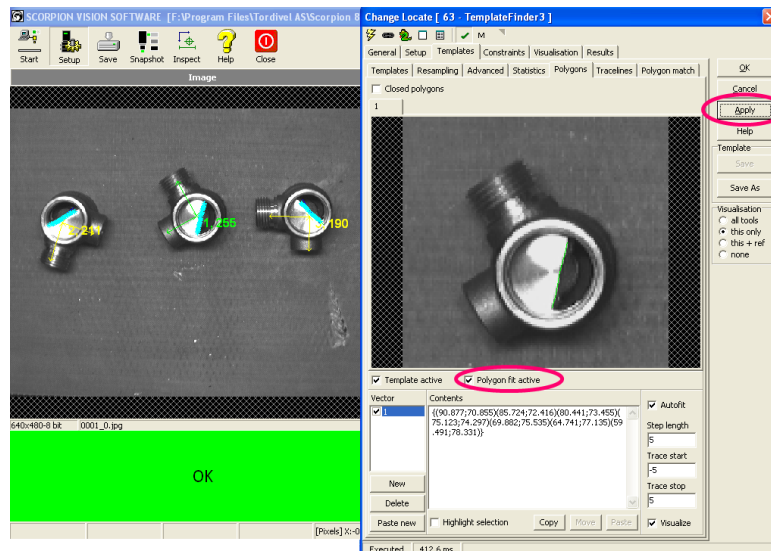


Figure 34: Polygon Matching

We have now configured TemplateFinder3 for polygon matching. Polygon matching works on the points from sides of the polygon and not on the area inside the polygon.

'Closed polygons' setting available on the polygon configuration dialog can be enabled to indicate polygons for which starting point and end point meet together.

Sequence of selection of points is important, we need to move ahead along a line while selecting points and should not go back in opposite direction. Otherwise geometry of the polygon will become incorrect with incorrect sides added to it.

Match scores also change, as polygon matching also affects them now along with template matching.

It also improves the orientation of the matches (center point as well as axes) since polygon matching works on sub-pixel level. It fine-tunes the results from template matching.

As per the configured traceline settings 'trace start', 'trace stop' and 'step length', every result from template matching are traced. Degrees of freedom (translation and rotation are enabled by default and we have used the same) are also taken into consideration while the tracing operation. Best fit matching points is the result of tracing operation on each object which is further processed to get best fit polygon position. The tracing operation works similar to edge detection and looks for contrast changes along the trace-line to get an edge point. We have used default settings for edge detection in this tutorial.

6. Reducing Processing Time

Many computations are involved in template matching operations and it can take long time to process one single captured image. This is not acceptable in production situations. TemplateFinder3 provides various settings to reduce processing time, and still maintaining good accuracy.

Scaling factor used in **re-sampling** of template image affects the overall processing time. Higher is the '**Original to resampled pixel ratio**', lesser is the processing time. This reduces the template image size.

However using very high scaling factor is not recommended as it will lower the accuracy.

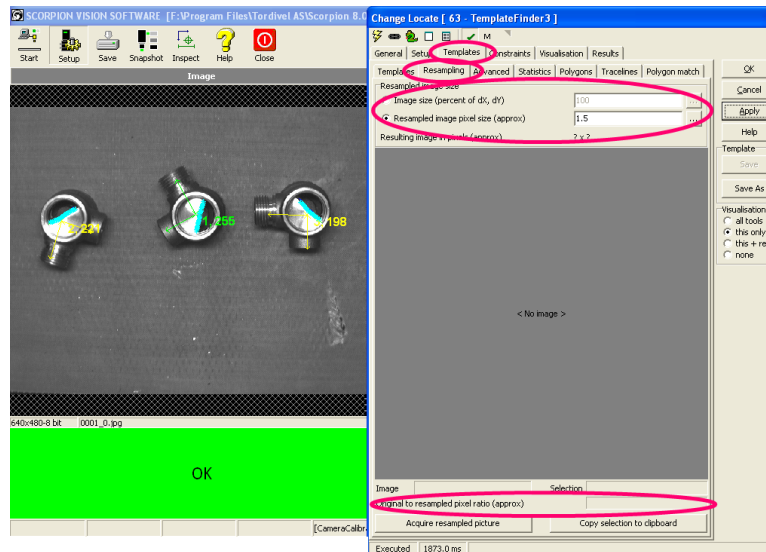


Figure 35: Re-sampling Scaling Factor

Under '**Advanced**' tab, there is a setting for '**Template decimation**'. This is related to further scaling down of the template during matching operation.

Higher is the decimation factor, more is the scaling down effect and more are the pixels removed from template. This helps in reducing the processing time, but increases risk of false detections and missed detections.

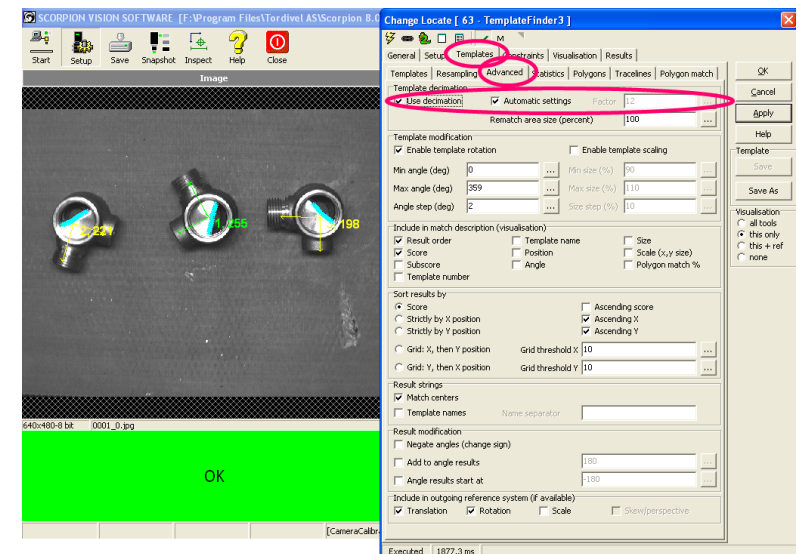


Figure 36: Decimation

Enabling '**Automatic settings**' for template decimation factor is ok in most of the cases. Manually setting the decimation factor to 7 should also give good results in most of the cases.

When 'Template rotation' is enabled, it increases the processing time.

'Angle step' for template rotation can be increased to lower the processing time. However it may affect the accuracy of matching.

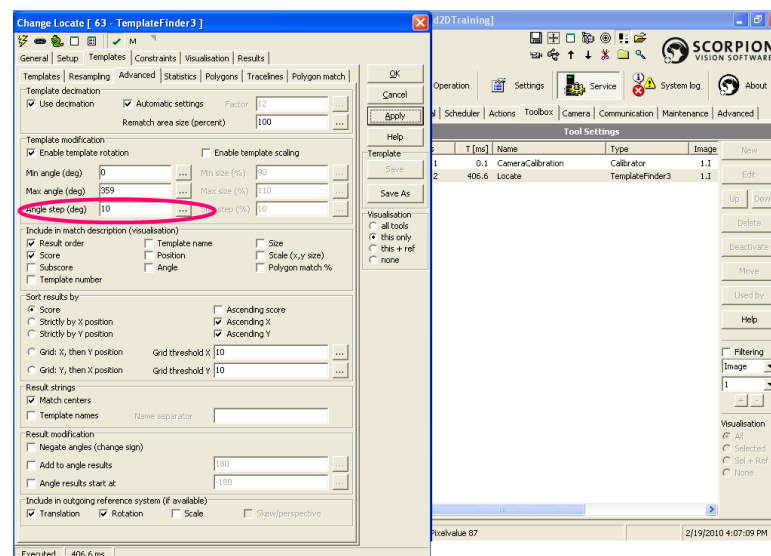


Figure 37: Angle Step for Template Rotation

Processing time needed for 'TemplateFinder3' tool is displayed after every cycle of 'TemplateFinder3' tool processing.

After changing settings, click on the 'Apply' button. This will process the currently captured image from image panel on main dialog. And this will also update the processing time (in milliseconds) needed for every tool under 'Toolbox'.

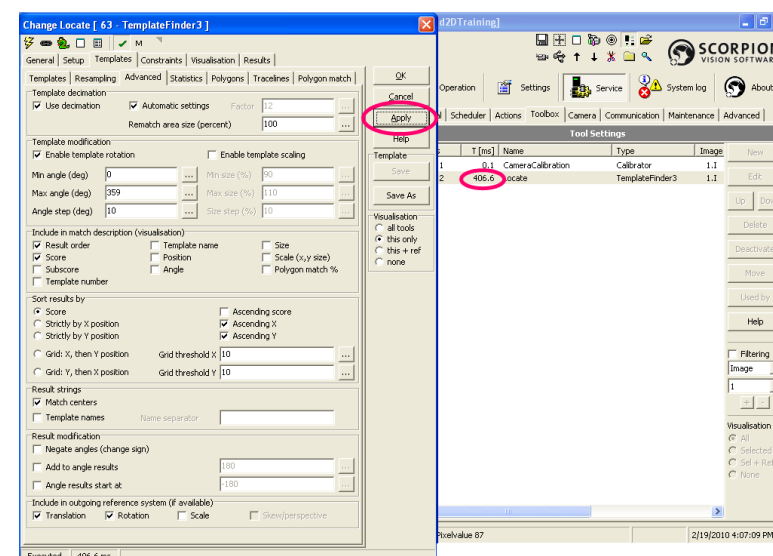


Figure 38: Checking Processing Time

7. Configuring Thresholds and Constraints

There are several thresholds and constraints associated with Template-Finder3 tool, which can be fine tuned to increase the matching accuracy.

Under 'Setup' tab, 'Image correlation setup' group is available.

'Threshold' setting from this group is associated with matching results. If match score for an object is higher than this threshold, then the object is considered as a match, otherwise it is considered as no match.

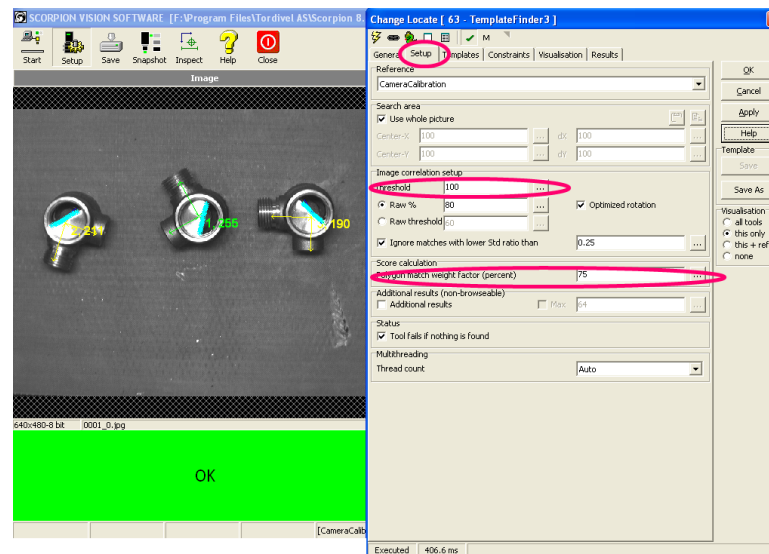


Figure 39: Threshold Setting

In 'Score calculation' group, there is a setting for 'Polygon match weight factor (percent)'. This indicates how much weightage should be given to polygon matching match score with respect to the template matching match score. These weightages affect the final match score which is combination of both template matching match score and polygon matching match score.

When polygon matching is disabled, its weightage is 0, so final match score is same as template matching match score.

During configuration tests, if false matches are observed, simple constraints can be enabled to eliminate the false matches.

Under 'Constraints' tab, there is a setting for 'Max no of matches'. This can be enabled and expected maximum number of objects and hence matches in a single captured image can be specified, to eliminate all other false matches.

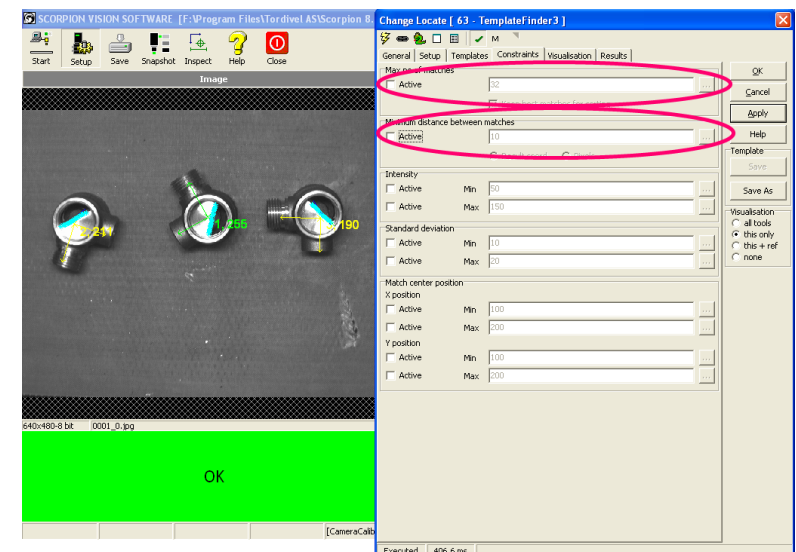


Figure 40: Constraints

There is also a setting 'Minimum distance between matches'. This can be enabled and expected minimum distance in pixels or result co-ordinates can be set. This will eliminate the false matches which are very close to other matches or even the overlapping with other matches.

8. Template Matching Advanced Configuration

In 'TemplateFinder3', we can also configure multiple templates, if required.

Steps for adding another template are same as those for adding first template (as described in this tutorial, **Section 4** - Re-configuring 'TemplateFinder3' Tool).

Acquire re-sampled image, copy it to clipboard and click on '+' button from 'Templates' sub tab to add the new template.

Each template can also be enabled or disabled independently by checking / un-checking 'Active' checkbox.

Also when a template is added, it is also available for polygon definition.

By default no polygon is defined and polygon fit is inactive for the newly added template.

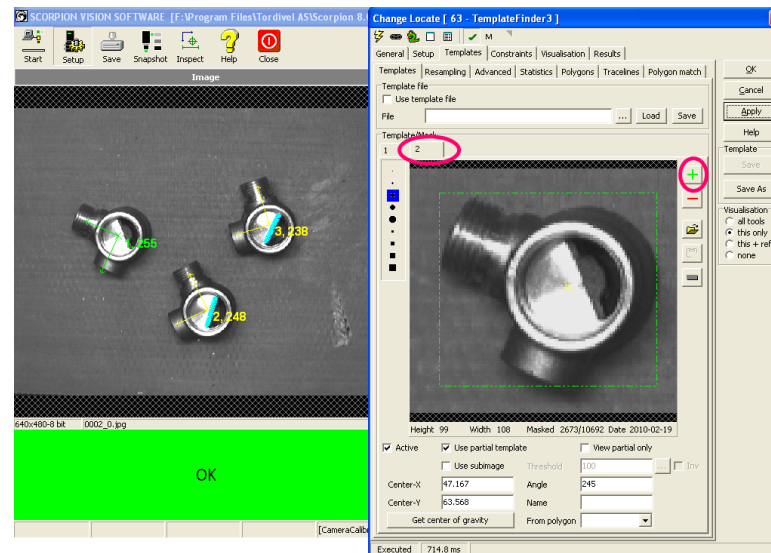


Figure 41: Adding 2nd Template

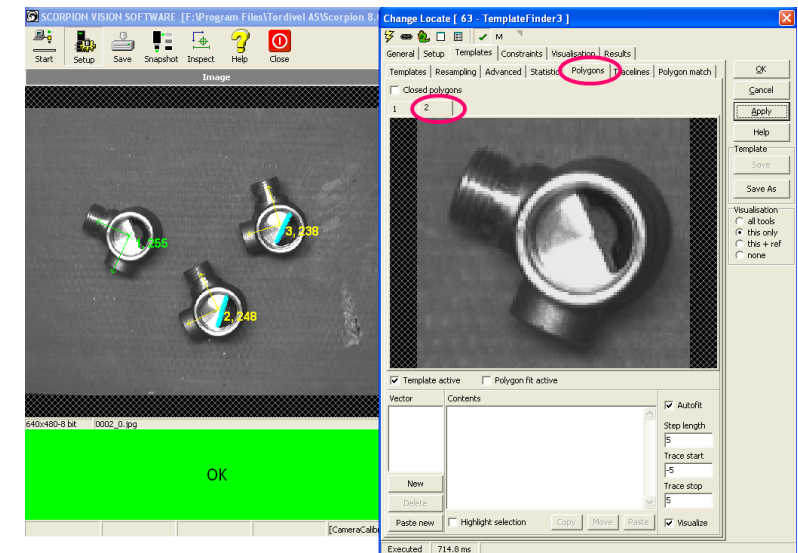


Figure 42: Polygons Tab

When new template is added, it shows tab '2' under 'Template/Mask' section.

'+' and '-' buttons can be used to add templates and remove templates respectively.

All settings like 'center', 'angle', 'use partial image' etc are available for every template separately.

Select the newly added template. Click on the '-' button to delete it.

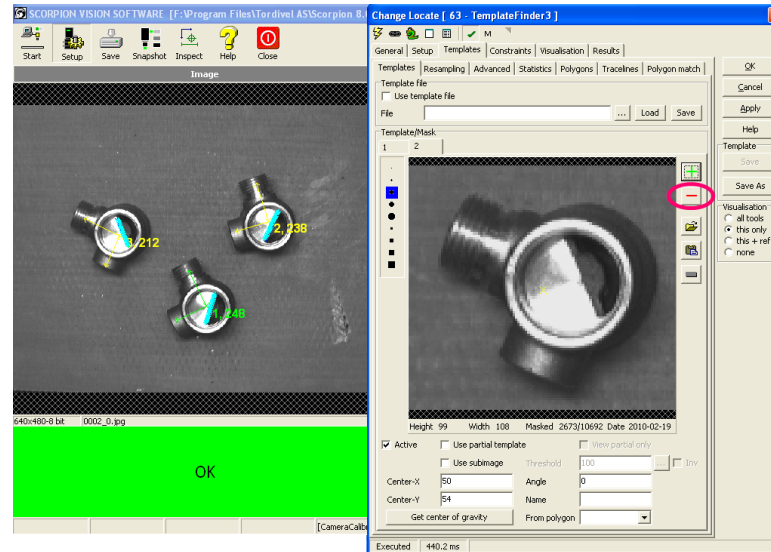


Figure 43: Delete Template

Some part of the template can be 'masked' or set to be ignored during matching.

For defining the mask, keep the CTRL key pressed and drag the mouse on the template area to be ignored. The masked area is displayed in pink color.

Keeping the SHIFT key pressed and dragging the mouse will erase the defined mask area.

Right clicking on the template image and selecting 'Reset mask' will remove the mask.

If 'Template rotation' is enabled, please disable 'Optimized rotation' from the 'Setup' tab so that masking is applied correctly during template rotation processing.

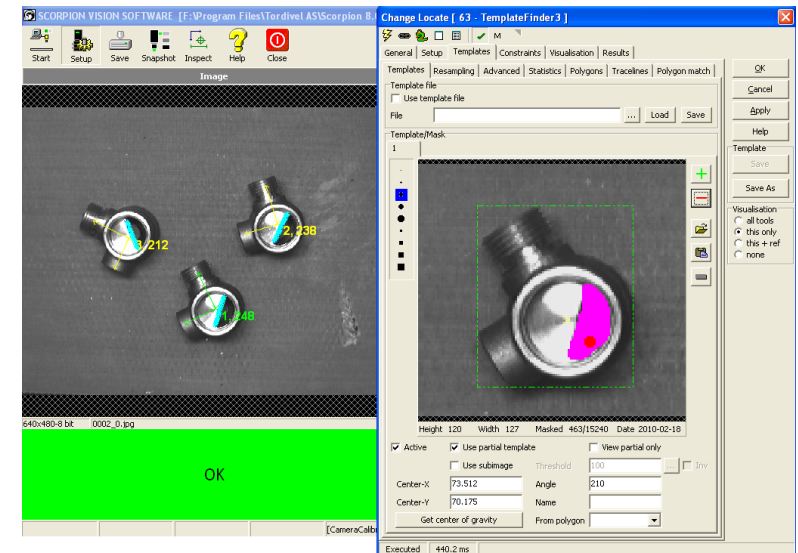


Figure 44: Masking

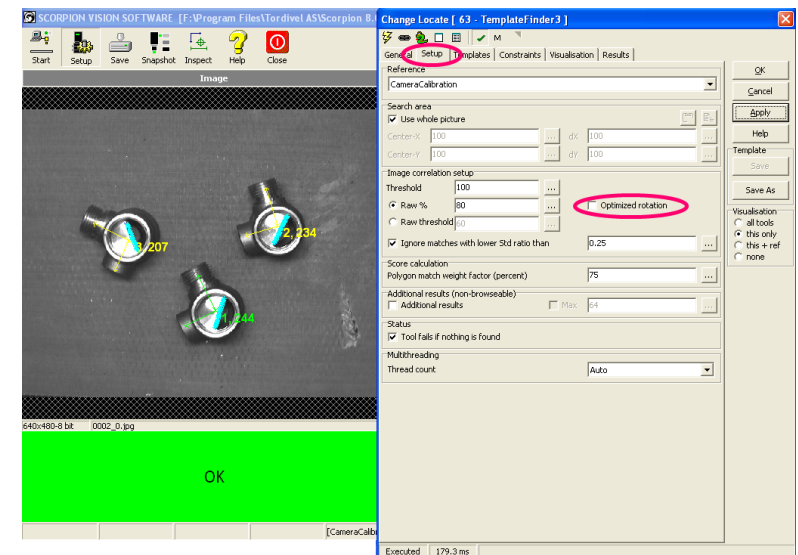


Figure 45: Disable 'Optimized rotation'

Multiple templates can be defined when multiple objects exist in the inspection set or there is larger variations in lighting conditions.

However this increases processing time. Completely new matching operation happens for each template, hence processing time for 'x' templates is approximately 'x' times the processing time for single template.

Polygon matching is associated to a single template. So separate polygon definition is needed for every template added.

Masking is useful feature when we have multiple objects which are only slightly varying, we can mask the region which is different across different objects and can use all other configuration as shared / single configuration and still get good results.

Masking can also be used in certain cases where missed matches are observed due to certain part of object. That part can be ignored to increase the overall accuracy.

By default 'Optimized rotation' is enabled. This used different algorithm which takes lesser processing time. However when masking is enabled, this algorithm does not consider masking while rotation and can create problems during matching. When 'Optimized rotation' is disabled, different algorithm is used which takes more processing time but it is able to manage the mask rotation during template rotation.

9. Polygon Matching Advanced Configuration

Multiple polygons can be defined for a template.

Steps for defining additional polygons are the same as the steps for defining the first polygon.

Keep the CTRL key pressed and click on the points on the polygon in fixed direction to define the polygon.

Click on the 'Paste new' button to add the newly defined polygon to the list of vectors with index '2'.

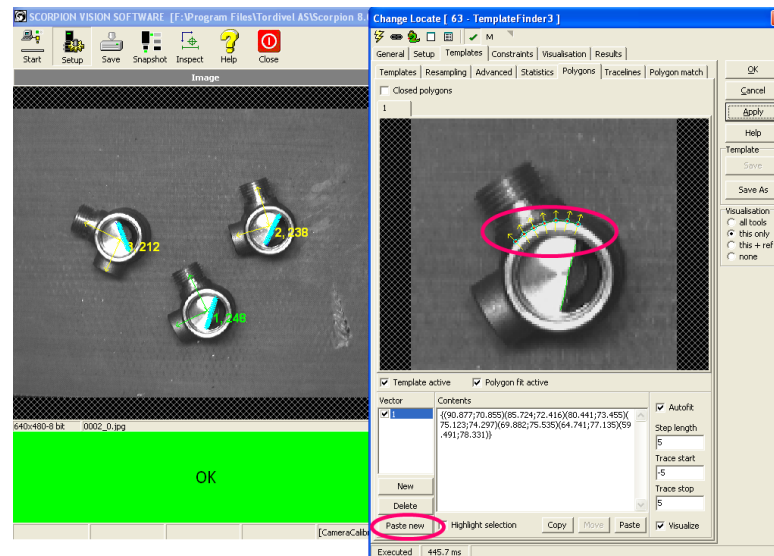


Figure 46: Define 2nd Polygon

Click on the 'Apply' button to see the results of matching with 2 polygons.

Each polygon can be individually set to active / inactive, from checkbox available in list of vectors

If required, custom settings can be defined for each polygon. Right click on the item '2' from the list of vectors which is related to the 2nd polygon and click on the 'Custom...' menu. This will pop up the 'Polygon properties' dialog box.

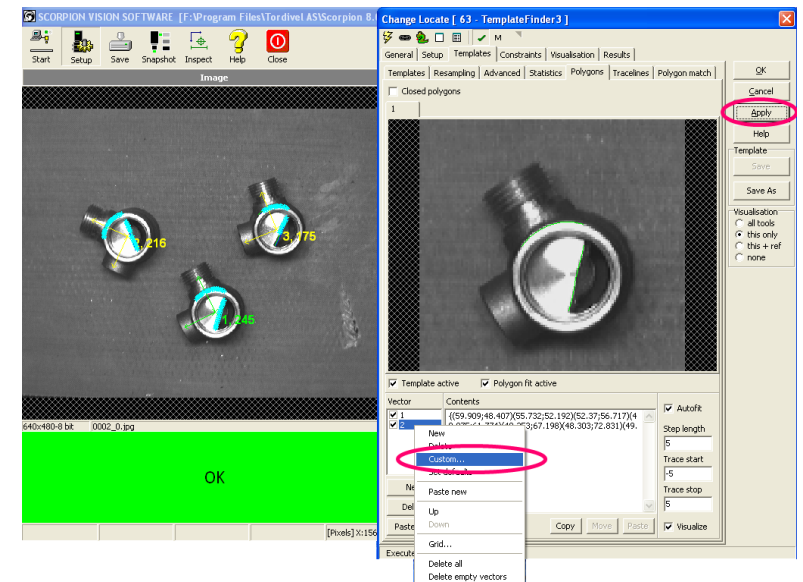


Figure 47: Custom Settings

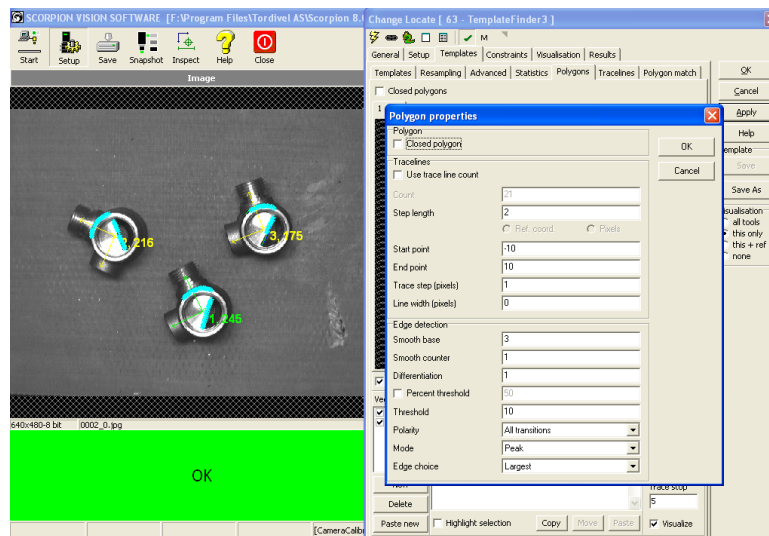


Figure 48: Custom Settings Dialog

Change settings and per the requirements and click on the 'OK' button to close the 'Polygon properties' dialog box.

The polygon which has customized settings is displayed in red color text in the list of vectors and also has asterisk mark associated with it.

When multiple polygons are defined, the final match score of polygon matching is the combined match score from all the polygons. Weightage of different polygons is proportional with the number of points defined for that polygon. So polygons with more number of points have larger influence on the final combined match score of polygon matching than the polygons with smaller number of points.

Number of points associated with a polygon depend on step length or trace line count if the trace line count is enabled and set.

By default, polygon match considers translation and rotation. Different polygons have different results depending on the degrees of freedom configured for polygon matching. E. g. polygon defined on a circle shape will not be able to correct rotation.

Its recommended to define polygon on clearly defined edges. Multiple polygons which have lines angled with each-other and make complex but defined shape give better results.

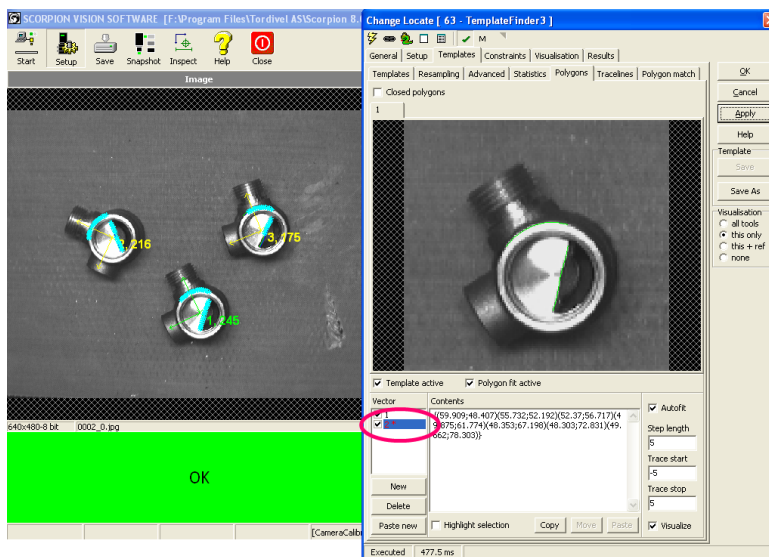


Figure 49: Polygon with Customized Settings

Congratulations!

You have successfully configured 'TemplateFinder3' tool available in Scorpion Vision Software, for training objects and locating them in the captured images!

10. Advanced Approach

Scorpion Vision Software provides an important feature, where trace-lines and match configurations can be defined separately for each polygon vector added during the TemplateFinder3 setup.

This feature can be used to configure TemplateFinder3 for more accurate, more robust and still faster 2D detection.

Preconfigured profile 'Advanced 2D Training_AdvancedApproach.zip' available with this tutorial demonstrates this advanced approach used for detecting the sample objects from the images captured by Scorpion.

In this section, we will set up a new TemplateFinder3 tool with the advanced approach, in the same 'My_Advanced 2D Training' profile, which we have configured in this tutorial.

Under the 'Service' mode, go to the 'Toolbox' tab.

Select the 'Locate' tool. Click on the 'Deactivate' button to deactivate it.

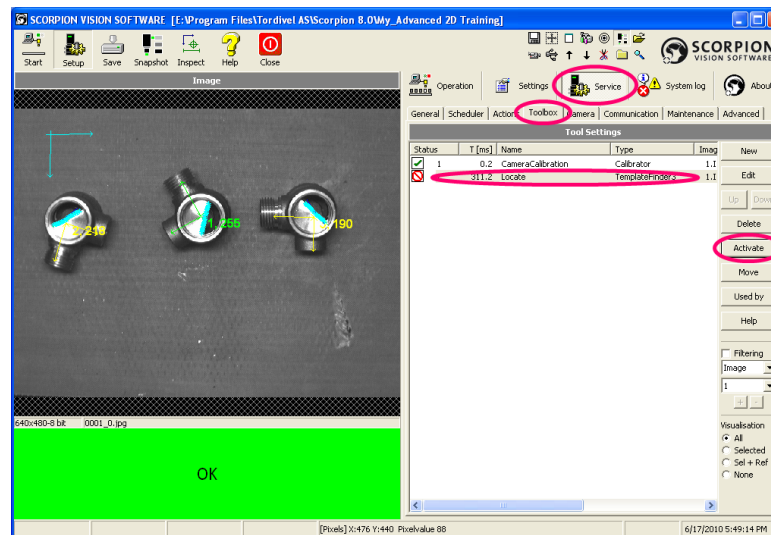


Figure 50: Deactivate Locate Tool

Click on the 'New' button. This will pop up the 'New Tool' dialog box.

Type the 'Name' as 'Locate2'.

Select the 'Advanced' category, and the 'TemplateFinder3' tool listed in it.

Click on the 'OK' button to close the 'New Tool' dialog box.

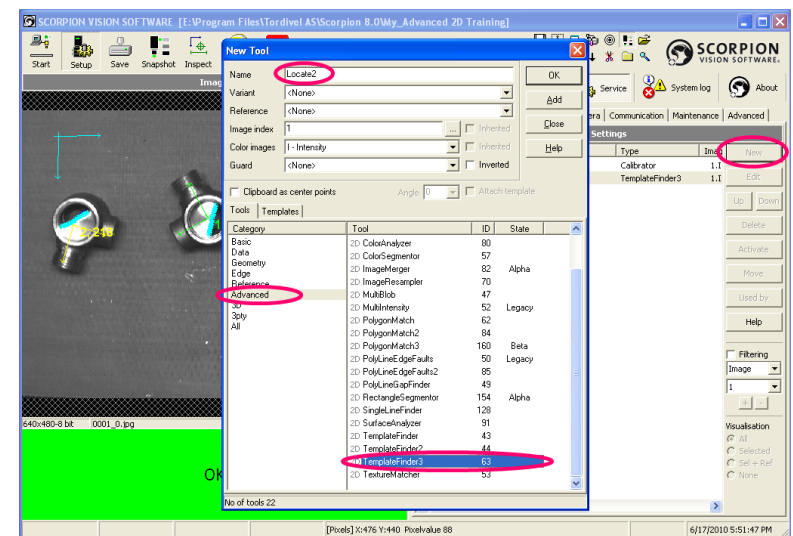


Figure 51: New TemplateFinder3 Tool

Select the newly added 'Locate2' tool from the list of tools.

Click on the 'Edit' button. This will pop up the 'Change Locate2 [63 - TemplateFinder3]' dialog box.

Go to the 'Setup' tab.

Select the 'Reference' as 'CameraCalibration'. Click on the 'Apply' button to update the reference.

Under the 'Search area' group, enable the 'Use whole area' check box.

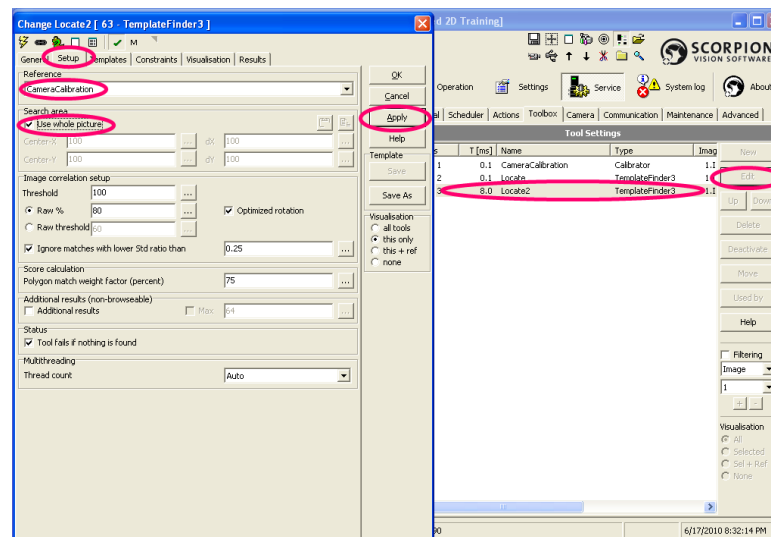


Figure 52: TemplateFinder3 Setup

Go to the 'Templates' tab and 'Resampling' sub-tab.

Select 'Resampled image size -> Resampled image pixel size (approx)' and set the value as 1.5.

Click on the 'Acquire resampled image' button. This will get the currently captured image (which is displayed in image panel on main dialog), re-sample it as per the re-sampling parameter, and will display the re-sampled image.

'Original to resampled pixel ration (aprox)' will now be displayed as 1.5:1.



Figure 53: Acquire Re-sampled Image

There are 3 objects available in the re-sampled image, we will use the middle one for training (during actual set up, any of the available objects can be used for training)

Click and drag using the mouse to draw a rectangle around the target object. The rectangle will be displayed as mouse is dragged on the re-sampled image.

Mouse button up will zoom into the re-sampled image only to show the zoomed selection rectangle. Zoom indicator icon is also displayed on the left-top corner of the re-sampled image.

Clicking on the re-sampled image will reset zoom and will show the original re-sampled image again.

We will keep the zoomed in view for training.

Click on the 'Copy selection to clipboard' button.

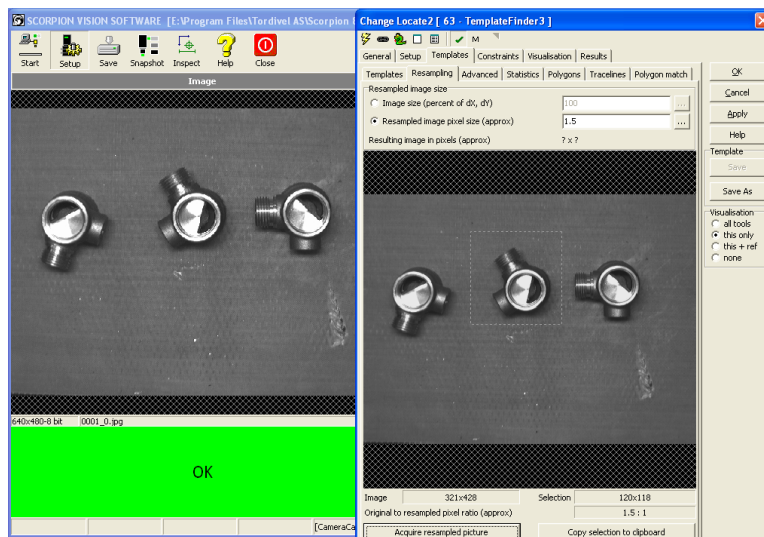


Figure 54: Zoom the Target Object

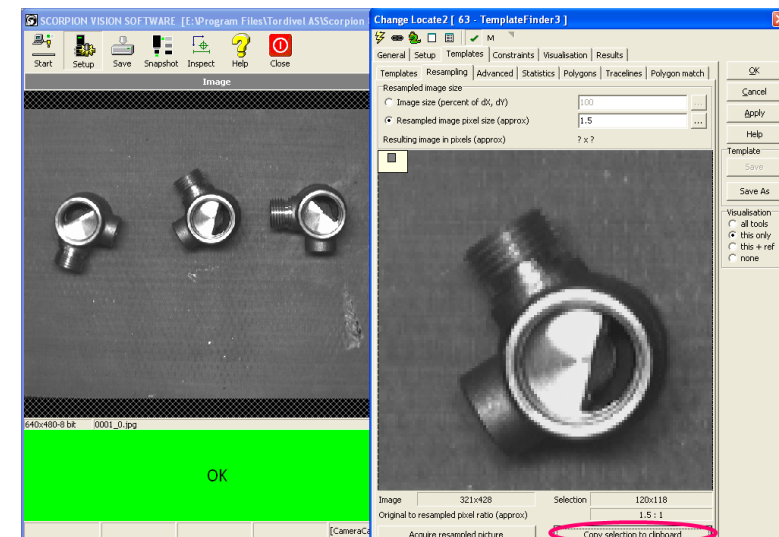


Figure 55: Zoomed Target Object

Go to the 'Templates' sub-tab.

Click on the '+' button to add template image. This is the same zoomed and re-sampled object image we copied to the clipboard recently.

Click on the 'Apply' button to see inspection results on the captured image displayed in the image panel on main dialog. It will show a green rectangle around middle object, indicating a match. Match score is displayed as 255. It's a perfect match since we have used the same object as template for training.

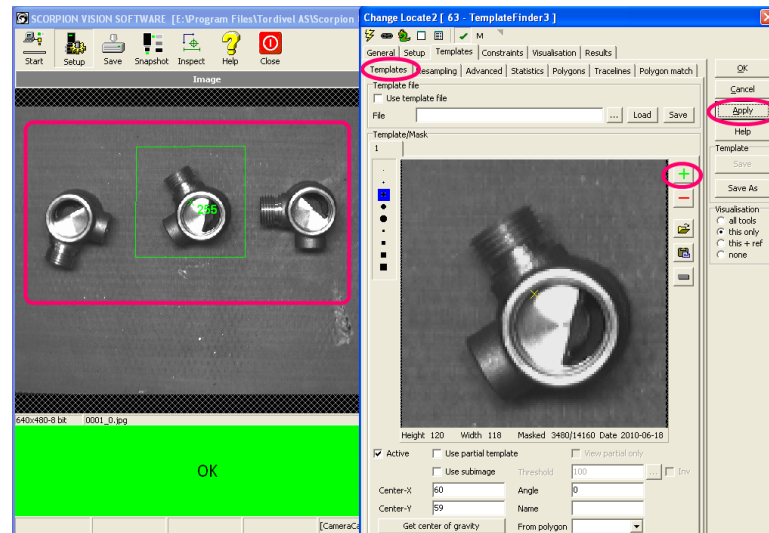


Figure 56: Add Template

Go to the 'Visualization' tab.

Select 'BestDescription', 'BestMatchAxes', 'BestMatchCenter', 'Description', 'Error', 'MatchAxes', 'MatchCenters', 'MatchedPoints', 'Polygon', 'Polygon-Orig' and 'ROI'. De-select all other visualizations.

Click on the 'Apply' button to see the new visualizations updated on the image panel from main dialog.

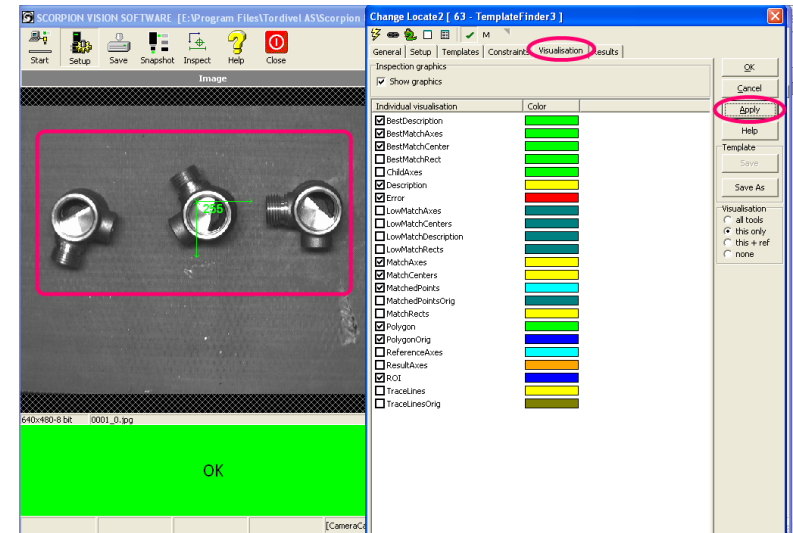


Figure 57: Configure Visualization

Go back to the 'Templates' tab and 'Templates' sub-tab.

It's important to set good reference, which is useful in reviewing the template matching results and making configuration updates easily.

For the current object being trained, **right click** at the center of the circular part of the object and select '**Set center**', to set that point as center of reference. Yellow cross indicating center of reference will move to the newly set center point.

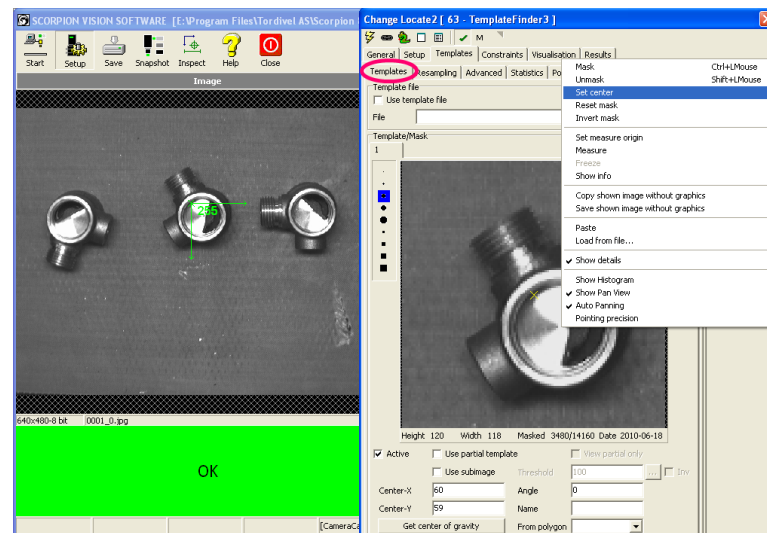


Figure 58: Set Center

Type '**Angle**' as 210.

Click on the '**Apply**' button to see the results on the currently captured image from image panel on the main dialog.

The axes are now aligned with the 2 protruding parts from the object. This reference can be good visual indication for 'good match'.

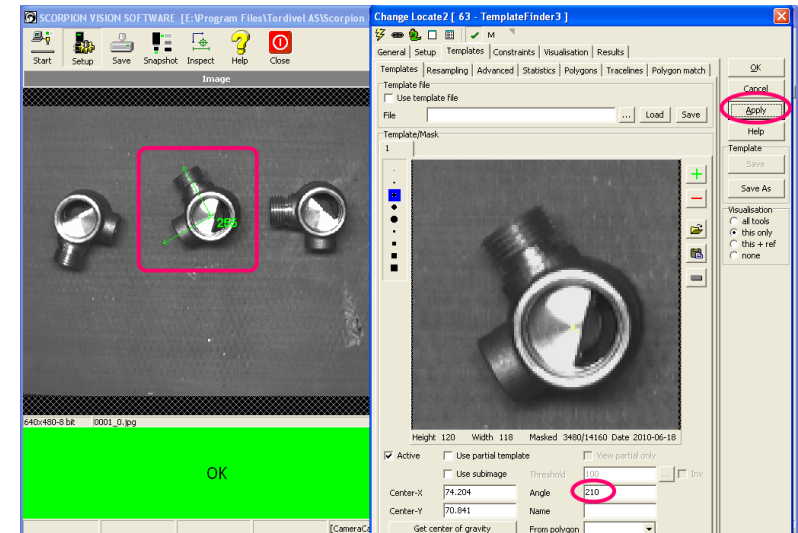


Figure 59: Set Angle

Enable the 'Use partial template' option. This will draw a green rectangle in dotted lines, on the template image.

This rectangle can be used to restrict the template matching only to specific rectangle within the template image. The green rectangle can be resized and moved using mouse while ALT keyboard button is pressed.

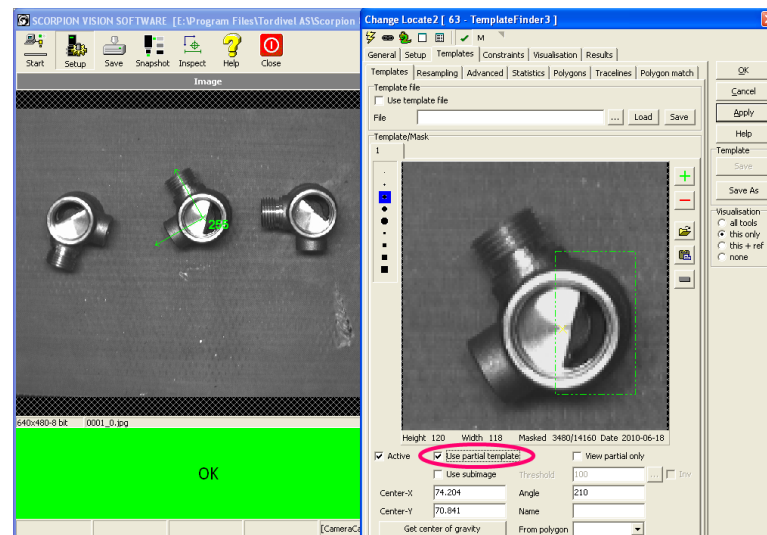


Figure 60: Use Partial Template

Mouse cursor changes to 'move' when its on any of the green rectangle sides and when ALT key is pressed. The green rectangle can be moved by dragging mouse from its sides while ATL key is pressed.

When mouse is at the corners of the green rectangle and ALT key is pressed, cursor changes further to 'cross-hair' indicate 'resizing'. The green rectangle can be resized from its corners by dragging mouse button while ALT key is pressed.

Use rectangle movement and resizing to fit the green rectangle around the hole, as demonstrated in the Figure 60.

Go to the 'Advanced' sub-tab.

Under the 'Template decimation' group, disable 'Automatic settings', and set the 'Factor' to 8.

Enable 'Template modification -> Enable template rotation'.

Enable 'Include in match description (visualization) -> Result order'.

Click on the 'Apply' button to see the effect of updated configuration on the currently captured image from image panel on main dialog.

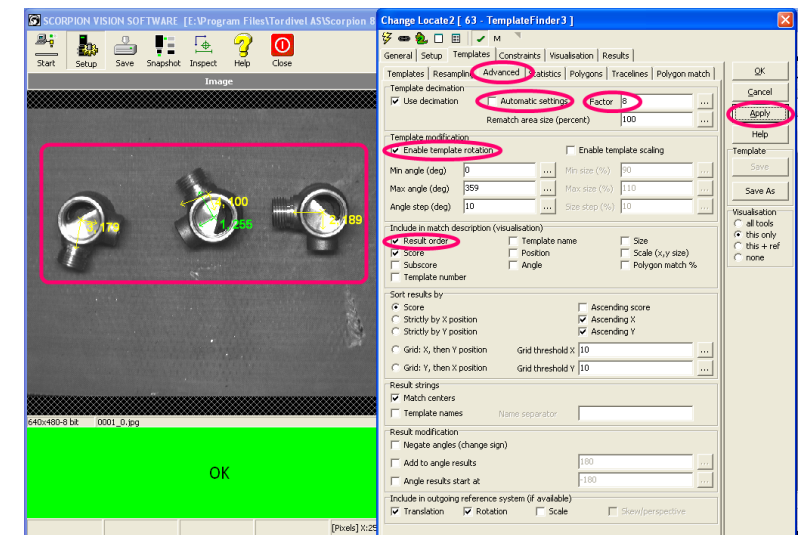


Figure 61: Advanced Settings

It is possible that a few false detections are observed, since we are using a much smaller template area. At this stage during the configuration, we will continue with these false detections. Later during the configuration, we will use 'custom match', which is an important feature available in the template matching; to eliminate the false detections.

Click on the 'OK' button to close the 'Change Locate2 [63 – TemplateFinder3]' dialog box.

Click on the 'Start' tool bar button to start the inspection.

Confirm that all objects from all captured images are detected and displayed as matches. There will be a few false detections, but we will ignore them at this stage.

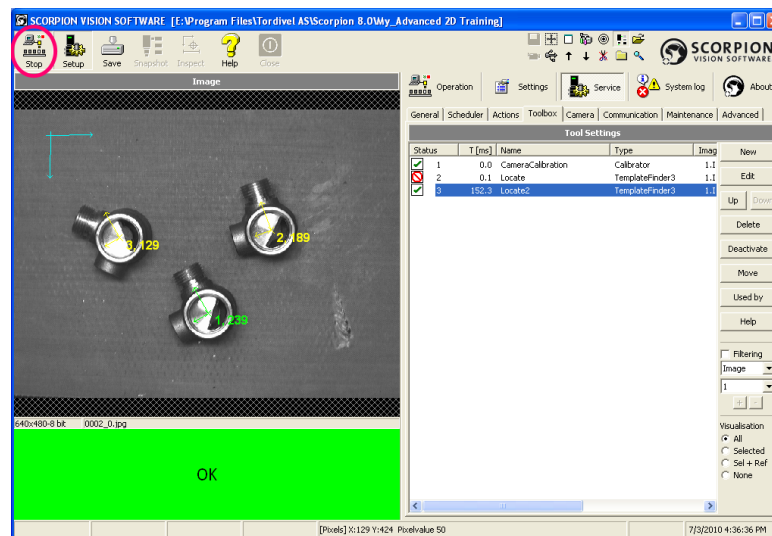


Figure 62: Inspection Test

Click on the 'Stop' tool bar button to stop inspection, if the inspection is going on.

Go to the 'Toolbox' tab.

From the list of configured tools, select the 'TemplateFinder3' type tool named 'Locate2'.

Click on the 'Edit' button. This will pop up the 'Change Locate2 [63 – TemplateFinder3]' dialog box.

Go to the 'Templates' tab and 'Polygons' sub-tab.

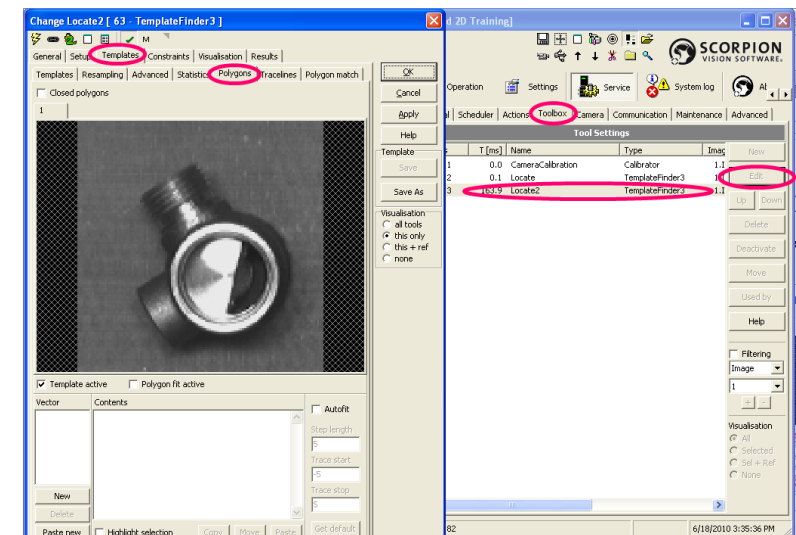


Figure 63: Edit 'TemplateFinder3'

The object has a circular part and an edge inside it. We will train this edge as a polygon.

Enable 'Autofit'.

Press CTRL key on the board. While CTRL key is pressed, click on the down-most point on the edge and go on clicking on the edge, moving up till we reach to the other end of the edge.

This will show arrows from the dark region towards the light region, across the edge.

The points also get re-adjusted, since we have enabled Autofit.

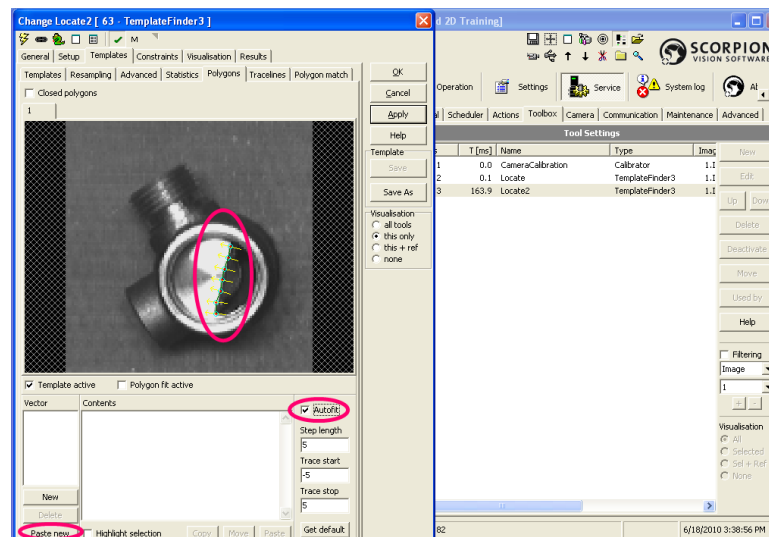


Figure 64: Define Polygon

Click on the 'Paste New' button. This will add a new polygon vector '1' to the list and include all selected points in it.

Right click on the newly added polygon vector '1', and click on the 'Custom trace...' menu. This will pop up the 'Polygon properties' dialog box. From this dialog box, properties specific to each polygon can be defined and fine tuning can be done to get more accurate results.

Under the 'Tracelines' group, set the 'Step length' to 4, 'Line width (pixels)' to 1.

Under the 'Edge detection' group, enable 'Percent threshold' and set its value to 50. Set the 'Min threshold' to 5. Select the 'Polarity' as 'Dark to light' and select the 'Edge choice' as 'Largest then nearest'.

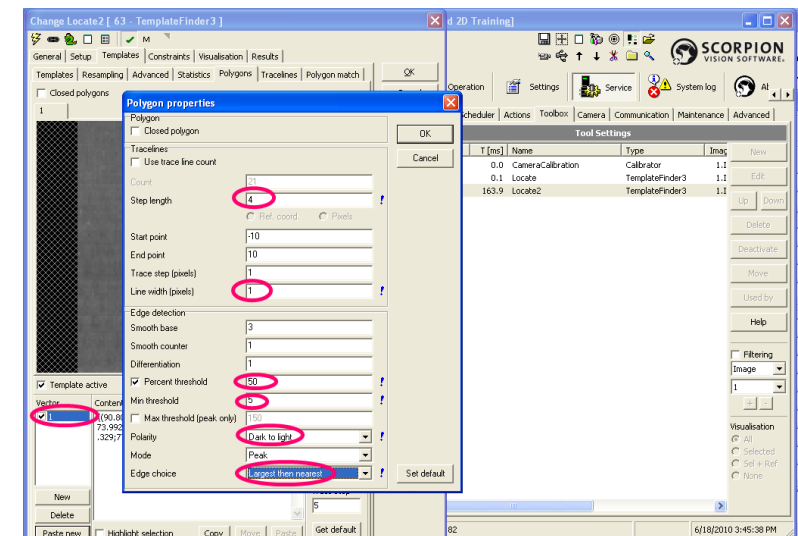


Figure 65: Polygon Properties

There will a blue exclamation mark (!) next to the updated parameters. This indicates that values of these parameters are not used from default/ common settings but are set as custom values for that specified polygon only.

Click on the 'OK' button to close the 'Polygon properties' dialog box.

Polygon vector '1' is now displayed in red text, indicating that it uses custom properties. Also there is 'T' letter added next to it, indicating that 'Custom trace' settings are configured for that polygon.

Enable on the 'Polygon fit active' check box to enable polygon matching.

Click on 'Apply' button to see polygon matching in action on the image from image panel on main dialog. Corresponding points in the objects are matched and highlighted in cyan color.

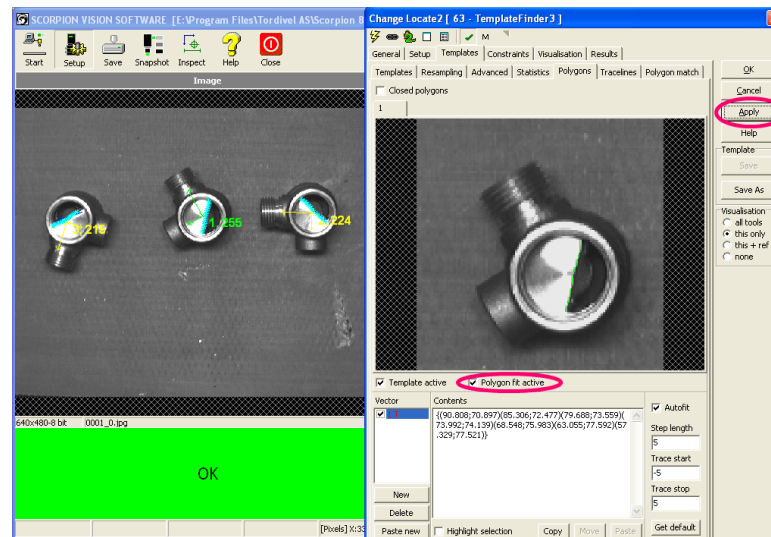


Figure 66: Polygon Matching

Match scores also change, as polygon matching also affects them now along with template matching.

It also improves the orientation of the matches (center point as well as axes) since polygon matching works on sub-pixel level. It fine-tunes the results from template matching.

To increase accuracy and robustness of the solution, we will define one more polygon. This will be the outer circle at the center of the part.

Press CTRL key on the board. While CTRL key is pressed, click on any point on the outer circle and go on clicking along the circle, moving anti-clockwise.

This will show arrows from the dark region towards the light region, across the circle.

The points also get re-adjusted, since we have enabled Autofit.

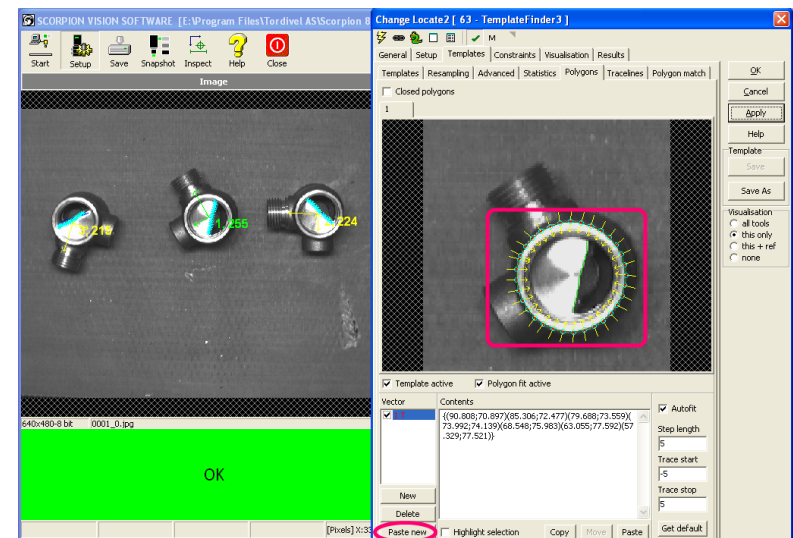


Figure 67: Define Polygon

Click on the 'Paste New' button. This will add a new polygon vector '2' to the list and include all selected points in it.

Right click on the newly added polygon vector '2', and click on the 'Custom trace...' menu. This will pop up the 'Polygon properties' dialog box.

Under the 'Polygon' group, enable the 'Closed polygon' option.

Under the 'Tracelines' group, set the 'Step length' to 20, 'Line width (pixels)' to 1.

Under the 'Edge detection' group, enable 'Percent threshold' and set its value to 50. Set the 'Min threshold' to 5. Select the 'Polarity' as 'Dark to light' and select the 'Edge choice' as 'Largest the nearest'.

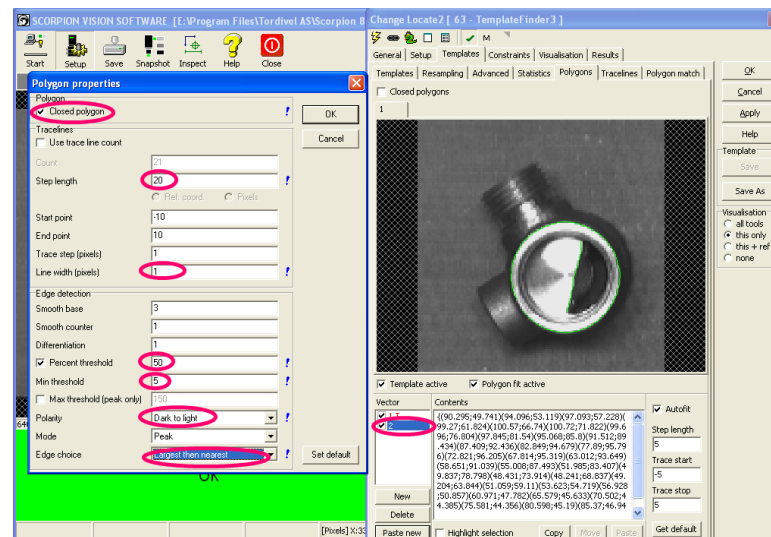


Figure 68: Polygon Properties

There will be a blue exclamation mark (!) next to the updated parameters. This indicates that values of these parameters are not used from default/common settings but are set as custom values for that specified polygon only.

Click on the 'OK' button to close the 'Polygon properties' dialog box.

Polygon vector '2' is now displayed in red text, indicating that it uses custom properties. Also there is a 'T' letter added next to it, indicating that 'Custom trace' settings are configured for that polygon.

Click on 'Apply' button to see polygon matching in action on the image from image panel on main dialog. Corresponding points in the objects are matched and highlighted in cyan color.

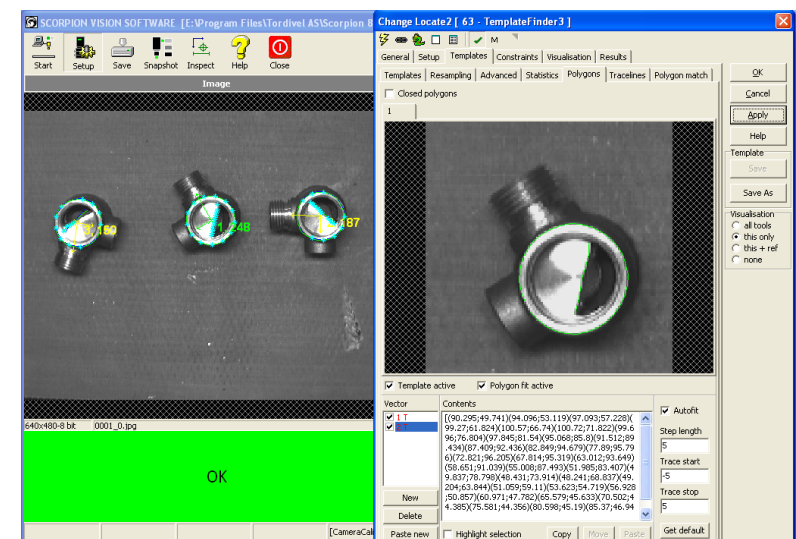


Figure 69: Polygon Matching

Go to the 'Polygon match' tab.

Under the 'Polygon match' group, set the 'Max repeat count' to 3.
Set the 'Final fit max distance (pixels)' to 4.

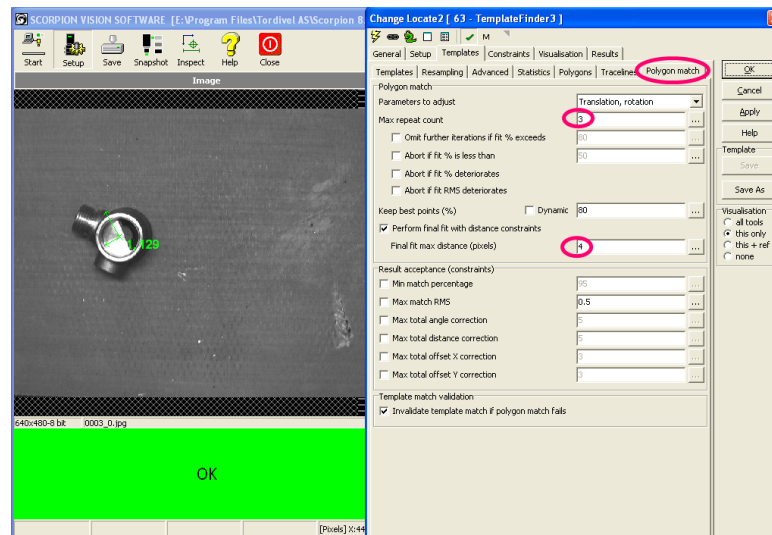


Figure 70: Polygon Match Settings

Go to the 'Templates' tab.

Go to the 'Polygons' sub-tab.

Right click on the polygon vector '1', and click on the 'Custom match...' menu. This will pop up the 'Polygon match properties' dialog box.

Enable the 'Min match percent' and set its value to 75. Also enable the 'Exclude from total match'.

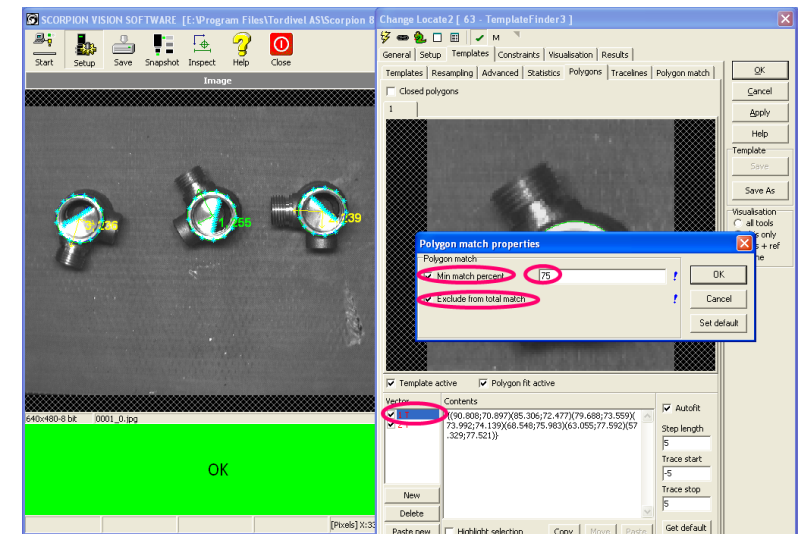


Figure 71: Custom Match

There will be a blue exclamation mark (!) next to the updated parameters. This indicates that values of these parameters are not used from default/common settings but are set as custom values for that specified polygon only.

Click on the 'OK' button to close the 'Polygon match properties' dialog box.

Polygon vector '1' is continued to be displayed in red text, indicating that it uses custom properties. Also there is 'M' letter added next to it, indicating that 'Custom match' settings are configured for that polygon.

Click on the 'OK' button to close the 'Change Locate2 [63 – TemplateFinder3]' dialog box.

Click on the 'Start' tool bar button to start the inspection, to confirm that polygon match works fine on all objects from all captured images. Since we have configured custom match for polygon 1, there are no false detections now and 100% accurate results are observed.

We have successfully configured the advanced approach. It is faster since it uses smaller template area.

This approach is also more accurate and more robust, since it uses 2 polygons. One of the polygons is the linear edge and another one is the circular edge, both of them when used alone have limitations. If only the circular polygon is configured, it can not identify the direction/orientation, and if only the linear polygon is configured, it may give many false matches as most of the objects would have many edges which would match the linear polygon. However, when both circular polygon and linear polygon are used together, they eliminate each other's limitations and provide more accurate and more robust results.

Custom properties configured for each polygon also help in improving the accuracy.

For the circular polygon, the 'Closed polygon' option is enabled.

For the circular polygon, the 'Step length' is set to 20, where as for the linear polygon, it is set to 4. This helps in controlling the number of points used on each polygon and hence controlling the weightage of each polygon. Since the circular polygon size is much bigger than the linear polygon, setting higher step length for the circular polygon helps in keeping the number of points on both polygons approximately similar.

Custom match configuration for particular polygons is another important feature which assists in increasing the accuracy.

The overall polygon match considers total number of points set on all the configured polygons. So in overall polygon match, it is possible that one or more polygons show very small match and still the final result is positive; which leads to false detections.

To avoid such false detections, custom match can be enabled for few critical polygons and match percentage for that polygon can be configured separately. This way the final result is positive when both the conditions are true - (a) overall polygon match score is higher than the specified threshold and (b) if custom match is defined for one or more polygons, the individual polygon match scores are higher than the custom match threshold set for that polygon.

Custom match for a polygon is a very powerful feature and is recommended to be used when there are multiple polygons configured in a TemplateFinder3 tool.

In the Advanced 2D Training_AdvancedApproach profile discussed in this section, if we disable custom match for the polygon 1, false detections are observed. However when custom match for the polygon 1 is enabled, there are no false detections, This highlights the power of the custom match feature available in polygon matching.

11. Tutorial Summary

We tried out the precompiled profile 'Advanced 2D Training' which has the 'TemplateFinder3' tool preconfigured.

Then we deleted the preconfigured 'TemplateFinder3' tool and re-configured it from scratch. The steps included acquiring scaled down re-sampled image, setting it as a template and doing template configurations, fine tuning visualizations, configuring for polygon match. We also reviewed important points like reducing processing time, advanced configurations, configuring multiple templates and configuring multiple polygons.

Finally we configured another 'TemplateFinder3' tool as per the advanced approach, which involved defining smaller template region, optimized polygon match settings, defining multiple polygons, using custom properties for each of the polygons and using custom match for polygon 1; to get the better accuracy.