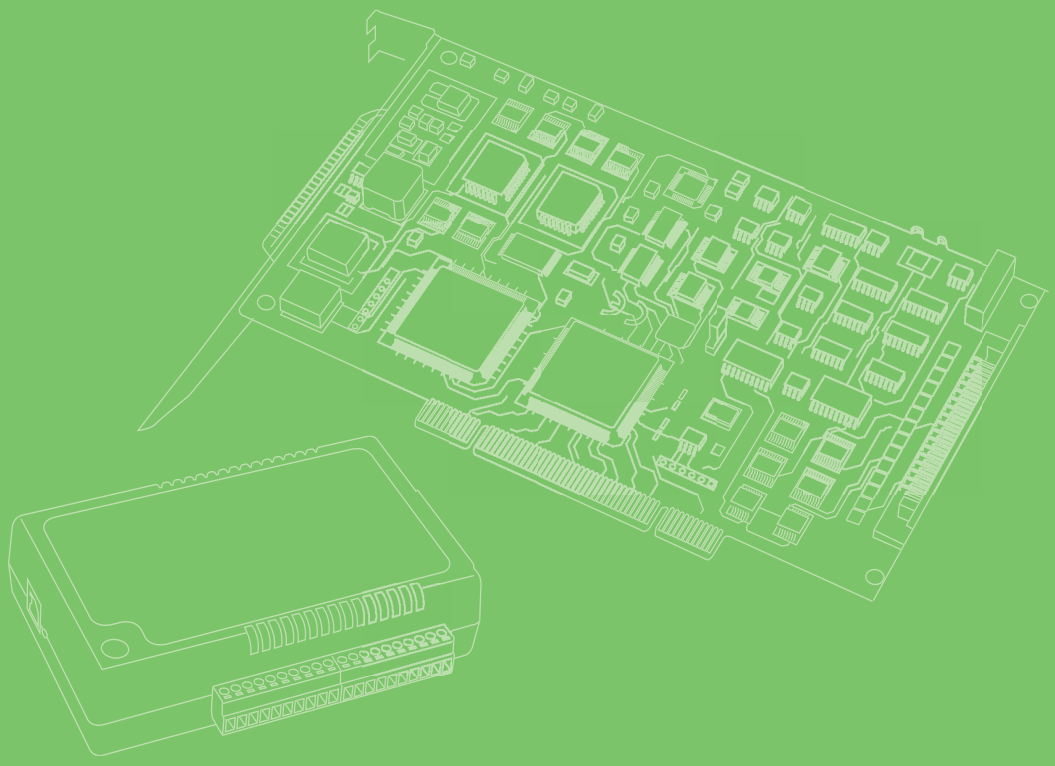

User Manual

Inspector Express

Tool Application Guide

ADVANTECH

Enabling an Intelligent Planet

Copyright

Acknowledgements

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Product Warranty (2 years)

Advantech warrants to you, the original purchaser, that each of its products will be free from defects in materials and workmanship for two years from the date of purchase.

This warranty does not apply to any products which have been repaired or altered by persons other than repair personnel authorized by Advantech, or which have been subject to misuse, abuse, accident or improper installation. Advantech assumes no liability under the terms of this warranty as a consequence of such events.

Because of Advantech's high quality-control standards and rigorous testing, most of our customers never need to use our repair service. If an Advantech product is defective, it will be repaired or replaced at no charge during the warranty period. For out-of-warranty repairs, you will be billed according to the cost of replacement materials, service time and freight. Please consult your dealer for more details.

If you think you have a defective product, follow these steps:

1. Collect all the information about the problem encountered. (For example, CPU speed, Advantech products used, other hardware and software used, etc.) Note anything abnormal and list any onscreen messages you get when the problem occurs.
2. Call your dealer and describe the problem. Please have your manual, product, and any helpful information readily available.
3. If your product is diagnosed as defective, obtain an RMA (return merchandize authorization) number from your dealer. This allows us to process your return more quickly.
4. Carefully pack the defective product, a fully-completed Repair and Replacement Order Card and a photocopy proof of purchase date (such as your sales receipt) in a shippable container. A product returned without proof of the purchase date is not eligible for warranty service.
5. Write the RMA number visibly on the outside of the package and ship it prepaid to your dealer.

Part No. 2003102400 Edition 1

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Declaration of Conformity

CE

This product has passed the CE test for environmental specifications when shielded cables are used for external wiring. We recommend the use of shielded cables. This kind of cable is available from Advantech. Please contact your local supplier for ordering information.

CE

This product has passed the CE test for environmental specifications. Test conditions for passing included the equipment being operated within an industrial enclosure. In order to protect the product from being damaged by ESD (Electrostatic Discharge) and EMI leakage, we strongly recommend the use of CE-compliant industrial enclosure products.

FCC Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Class B

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FM

This equipment has passed the FM certification. According to the National Fire Protection Association, work sites are classified into different classes, divisions and groups, based on hazard considerations. This equipment is compliant with the specifications of Class I, Division 2, Groups A, B, C and D indoor hazards.

Technical Support and Assistance

1. Visit the Advantech web site at www.advantech.com/support where you can find the latest information about the product.
2. Contact your distributor, sales representative, or Advantech's customer service center for technical support if you need additional assistance. Please have the following information ready before you call:
   - Product name and serial number
   - Description of your peripheral attachments
   - Description of your software (operating system, version, application software, etc.)
   - A complete description of the problem
   - The exact wording of any error messages
3. Online help: Fingertip help is available on every screen (panel) of the Inspector Express User Interface

Warnings, Cautions and Notes

Warning! *Warnings indicate conditions, which if not observed, can cause personal injury!*

Caution! *Cautions are included to help you avoid damaging hardware or losing data. e.g.*

There is a danger of a new battery exploding if it is incorrectly installed. Do not attempt to recharge, force open, or heat the battery. Replace the battery only with the same or equivalent type recommended by the manufacturer. Discard used batteries according to the manufacturer's instructions.

Note! *Notes provide optional additional information.*

Document Feedback

To assist us in making improvements to this manual, we would welcome comments and constructive criticism. Please send all such - in writing to:
http://support.advantech.com.tw/

Safety Instructions

1. Read these safety instructions carefully.
2. Keep this User Manual for later reference.
3. Disconnect this equipment from any AC outlet before cleaning. Use a damp cloth. Do not use liquid or spray detergents for cleaning.
4. For plug-in equipment, the power outlet socket must be located near the equipment and must be easily accessible.
5. Keep this equipment away from humidity.
6. Put this equipment on a reliable surface during installation. Dropping it or letting it fall may cause damage.
7. The openings on the enclosure are for air convection. Protect the equipment from overheating. DO NOT COVER THE OPENINGS.
8. Make sure the voltage of the power source is correct before connecting the equipment to the power outlet.
9. Position the power cord so that people cannot step on it. Do not place anything over the power cord.
10. All cautions and warnings on the equipment should be noted.
11. If the equipment is not used for a long time, disconnect it from the power source to avoid damage by transient overvoltage.
12. Never pour any liquid into an opening. This may cause fire or electrical shock.
13. Never open the equipment. For safety reasons, the equipment should be opened only by qualified service personnel.
14. If one of the following situations arises, get the equipment checked by service personnel:
15. The power cord or plug is damaged.
16. Liquid has penetrated into the equipment.
17. The equipment has been exposed to moisture.
18. The equipment does not work well, or you cannot get it to work according to the user's manual.
19. The equipment has been dropped and damaged.
20. The equipment has obvious signs of breakage.
21. DO NOT LEAVE THIS EQUIPMENT IN AN ENVIRONMENT WHERE THE STORAGE TEMPERATURE MAY GO BELOW -20° C (-4° F) OR ABOVE 60° C (140° F). THIS COULD DAMAGE THE EQUIPMENT. THE EQUIPMENT SHOULD BE IN A CONTROLLED ENVIRONMENT.
22. CAUTION: DANGER OF EXPLOSION IF BATTERY IS INCORRECTLY REPLACED. REPLACE ONLY WITH THE SAME OR EQUIVALENT TYPE RECOMMENDED BY THE MANUFACTURER, DISCARD USED BATTERIES ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS.
23. The sound pressure level at the operator's position according to IEC 704-1:1982 is no more than 70 dB (A).

DISCLAIMER: This set of instructions is given according to IEC 704-1. Advantech disclaims all responsibility for the accuracy of any statements contained herein.

Safety Precaution - Static Electricity

Follow these simple precautions to protect yourself from harm and the products from damage.

- To avoid electrical shock, always disconnect the power from your PC chassis before you work on it. Don't touch any components on the CPU card or other cards while the PC is on.
- Disconnect power before making any configuration changes. The sudden rush of power as you connect a jumper or install a card may damage sensitive electronic components.

About this manual

This manual serves as an application guide for the Inspector Express software toolkit. It shows how the tools can be used to solve a variety of inspection challenges. The information described herein is relevant for EagleEye and PC installations starting with version 1.8.0.0. For in-depth instruction on how to setup these tools, please refer to the Inspector Express Software Users Manual that ships with the product.

When reading this manual, keep in mind that there are many different ways to go about solving a vision application. In fact, some fairly complex inspection tasks can often be solved using fairly simple techniques. Of course we recognize that such techniques may not be obvious to the new vision adopter, but we hope that the sampling of applications described here will provide a good foundation for getting started.

We should also point out that this manual does not mention the Script Tool. This is an advanced tool in Inspector Express that allows you to construct scripts or small programs used mainly for communication with external devices. Refer to the “Inspector Express Scripting User Manual” for details.

Contents

Chapter 1

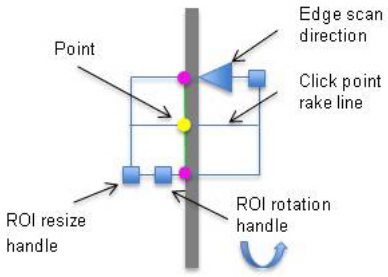
Tool Application Guide

1.1 Tools

1.1.1 The Point Tool

The Point tool can be used to locate the exact position of a point along an edge. The tool fits a line to the edge and reports the intersection of the line with a perpendicular (rake) line passing through the user's click point. The Point tool finds edge points used in the line fit algorithm by scanning along invisible lines inside its ROI. Additional edge points can be added to improve accuracy and the ROI can be resized to reference more or less of the edge.

Point tools are often used as locators to facilitate the application of other tools. A single point defined as a "positional anchor" will provide XY positional information to any tool referencing it. Adding a second "rotational anchor" point (referenced to the 1st) will also provide angle of orientation.



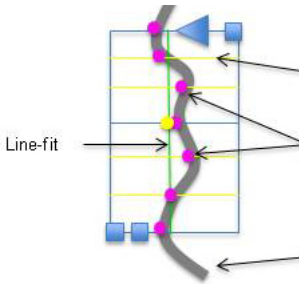
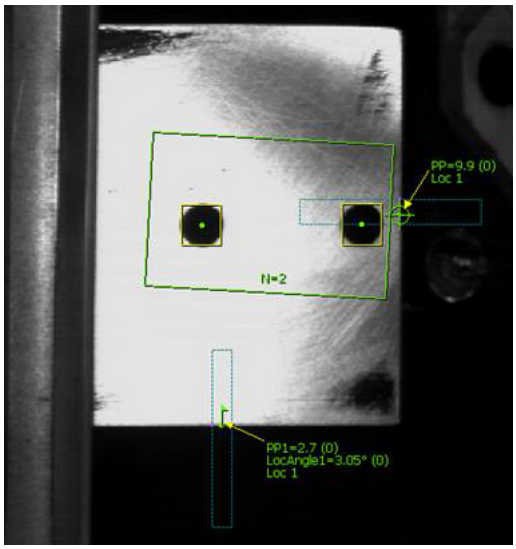


Table 1.1: Point Tool Facts	
Supports ROI shapes	Point (edge search area on each end)
Tool creation	Click on any edge
Measurements	Position deviation and XY coordinates
Scan direction	Determined by search ROI
Edge choice	Strongest, First or Last
Edge transition	Automatic with sensitivity slider
# Rake Lines	2-50 points (3 default)

An application of the Point tool is shown below. Two Point tools are used to locate the right and bottom edges of a welded plate. The point information is used to align a count tool to ensure that two holes are drilled through the plate for assembly.



Many tools in Inspector Express create Point tools for alignment or measurement. Various applications of the Point tool will be illustrated throughout this manual. When considering how to go about developing your application, you will find that there are often many different paths to a successful implementation.

Note! *Several Inspector Express tools use the Point tool algorithm to locate edges and edge points.*

1.1.2 The Pencil Tool

The Pencil tool is used to establish a reference line from which other measurements can be made. For example, a Distance or Angle tool can use a Pencil tool as an anchor. A Pencil tool can be created along an image edge or where no edges are present i.e. a “floating” reference.

When you create a Pencil line along an image edge, the tool will lock onto the 1st click point and trace the edge as you move the mouse. The 2nd click point will define the end of the Pencil line. In this case the Pencil line will create 2 Point tools along the edge that define the slope or angle of the line. If the end click point is not on an edge, the tool will create the 2nd Point tool along the edge on which the Pencil line was started. Once created, the Point tools define the anchors for the Pencil tool. They can be moved and resized by selecting the Point tool in the tool box. If you create a Pencil line that is not referenced to an edge, then no anchor points will be created.

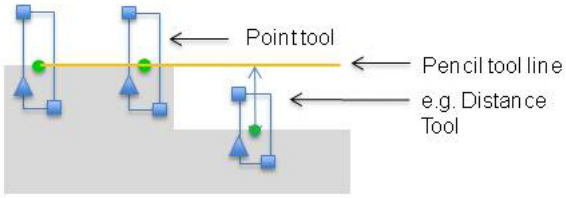
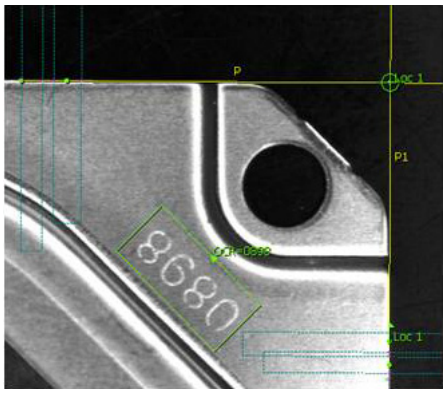


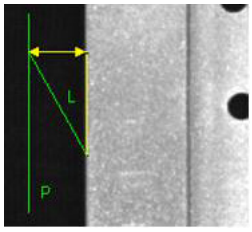
Table 1.2: Pencil Tool Facts	
Supports ROI shapes	Straight Line
Tool creation	2 click points on starting and ending points
Scan direction	Determined by search ROI
Edge choice	Strongest, first or last on anchor points
Edge transition	Automatic with sensitivity slider
Pencil slope	Relative to starting point and Y axis

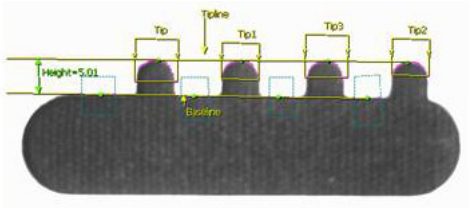
Note! *You can attach additional Point tools to a Pencil line. With the tool selected, click and drag a new Point tool onto the line as a new anchor. The Pencil tool line is essentially a best-fit line between all Point tools that define it.*

The example below shows how two Pencil lines can be used to locate the top and right edges of a part to align the OCR tool. The intersection point of the lines is used as a positional locator and one of the points on the right Pencil line is used as the anchor locator to determine angle. The points on each Pencil line are determined by the first dark-to-light edge in their respective search area. The search areas of the points have been extended to accommodate rotational movement of the part.



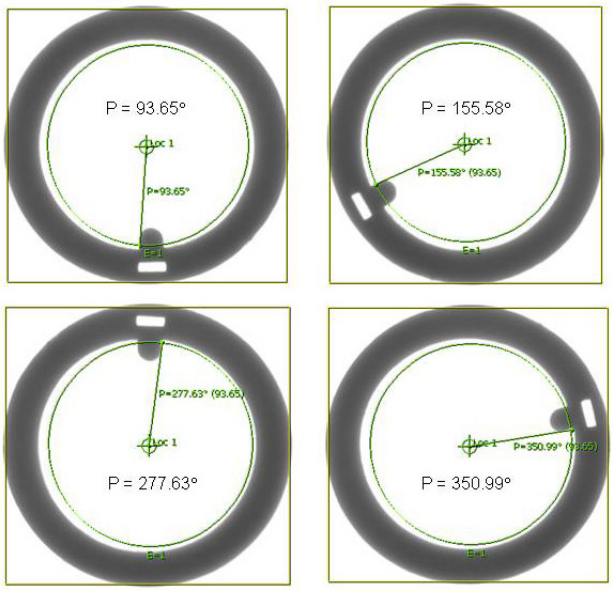
The left image below shows an example of a pencil line being used as a floating reference for a distance measurement. The right image shows how multiple points are used to construct pencil lines to make an average distance measurement.





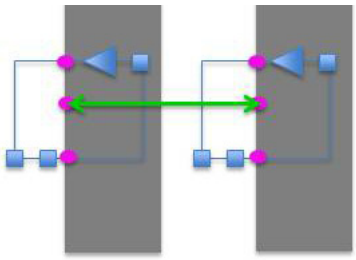
The slope measurement from the Pencil tool can be used to report the orientation of a part. This can be used to guide a robot to perform pick and place or assembly correction. The following example uses a count tool to find the center of the circular blob and an edge tool to find the key that can be positioned at any orientation about the center. A Pencil tool between the center point and the active edge point on the key returns the angle relative to the baseline.

Note! In this case the Pencil tool defines a positive angle in the clockwise direction relative to the left handed XY origin. The baseline is defined as the x-axis of the primary point i.e. the point defining the starting point of the Pencil.



1.1.3 The Distance Tool

The Distance tool is used to measure the distance between two *features*. Supported features are image edges (image borders), ROI edges or Points generated from other tools. For good accuracy, both edges should be straight within the ROIs on either end.



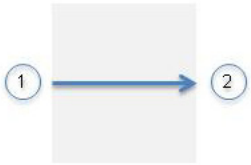
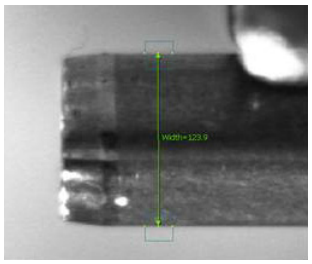


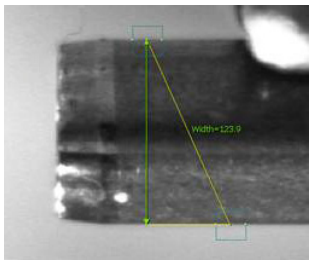
Table 1.3: Distance Tool Facts	
Supports ROI shapes	Rectangle (Edge search area on each end)
Tool creation	2 click points on starting and ending points
Scan direction	Dark to bright
Edge transition	Automatic with sensitivity slider

When anchored on an image edge, the Distance tool always scans for a dark-bright transition. When a Distance tool is created on an image, this scan direction is determined automatically. If the direction is wrong or needs to be changed because you moved the anchor box to a different edge, you can use the rotation control point to change the scan direction.

This image below shows the distance between the selected edge features in pixel measurements, defined by the resolution of the camera sensor. The software supports calibration of pixel to real world measurements.

If the two edges being measured are fairly straight and parallel, the Distance tool can measure the perpendicular distance between them. This means that you don't have to be too careful constructing a distance measure between two parallel edges.





The ends of a Distance tool can be anchored on a Pencil tool, a Point tool, or any of the four boundaries of the image.

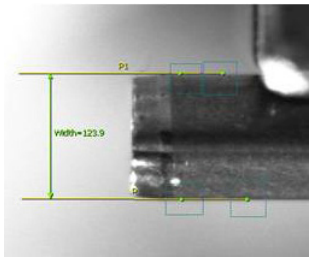


Image showing distance tool attached to Pencil lines

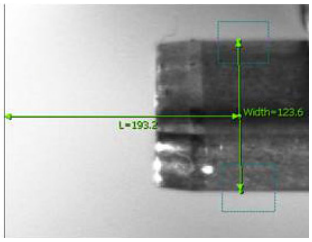


Image showing distance tool attached to center point of another distance measure and image edge.

1.1.4 The Rake Tool

The Rake tool is a variation of the Distance tool. Effectively, it creates multiple instances of the Distance tool and reports the average, minimum and maximum distance of the rake points. It also reports the standard deviation.

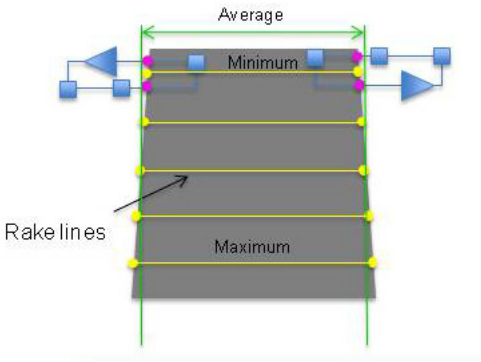
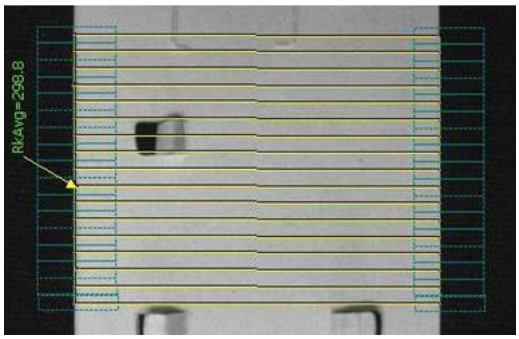


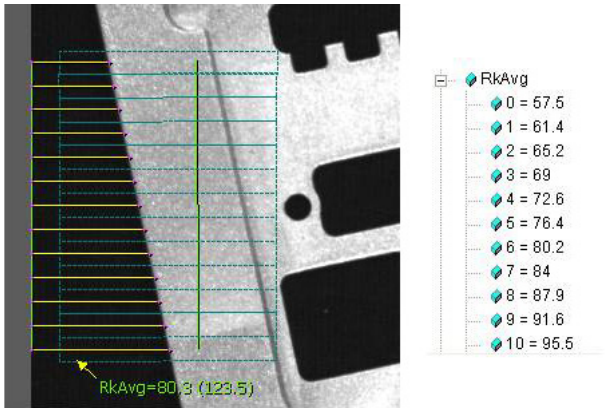
Table 1.4: Rake Tool Facts	
Supports ROI shapes	Rectangle (Edge search area on each end)
Tool creation	4 click points on starting and ending features
Scan direction	Dark to bright
Edge transition	Automatic with sensitivity slider
Accuracy	# of rake lines (up to 64)

When anchored on an image edge, the Rake tool always scans for a dark-bright transition. When a Rake tool is created on an image, this scan direction is determined automatically. If the direction is wrong or needs to be changed because you moved the anchor box to a different edge, you can use the rotation control point to change the scan direction.

The Rake tool makes a number of distance measurements at regular intervals between two edges. It is useful for measuring how uniform the separations between the edges are.



The Rake tool can use the boundaries of an image or a Pencil line as anchor. Individual lengths from the Rake are available for use in equations.



1.1.5 The Angle Tool

The Angle tool is used to measure the angle between two features. Supported features are image borders, image edges and Pencil lines. For good accuracy both edges should be straight within the ROIs on either end.

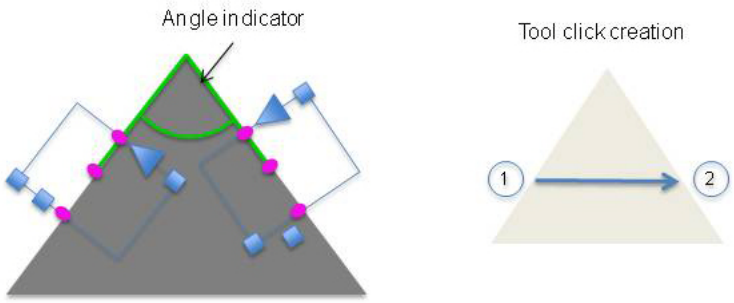
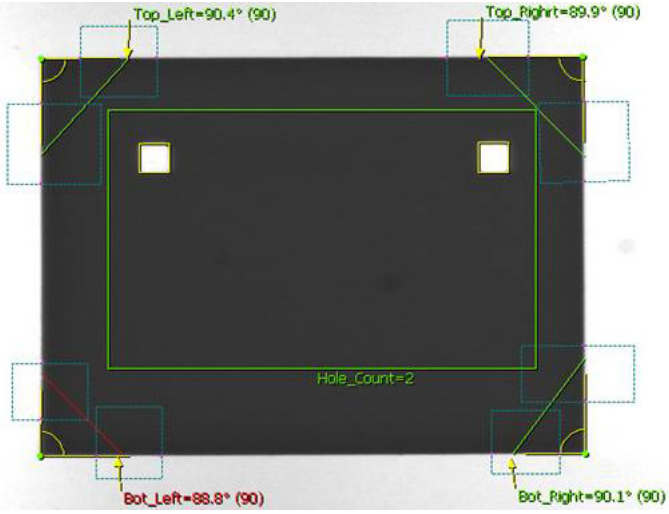


Table 1.5: Angle Tool Facts	
Supports ROI shapes	Rectangle (Edge search area on each end)
Tool creation	1 click point on each angle edge
Scan direction	Determined by search ROI
Edge transition	Automatic with sensitivity slider
Accuracy	2 to 50 rake points within search ROI

The Angle tool is used to measure the cut accuracy of each corner on a metal plate. Each corner is expected to 90? +/- 0.5?. In this example the left bottom corner is out of specification.



The Angle tool is also useful for locating the intersection point (corner) of two edges. This point may be used as a locator in applications where the defining edges are straight and part movement is small.

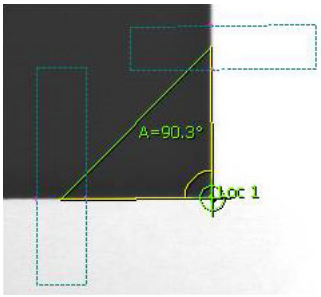


Image showing bottom left corner point being used as a locator to align other tools.

1.1.6 The Tip Tool

The Tip tool is a variation of the point tool that locates the extremity (tip) of a corner or edge. Like the Point tool, the Tip tool scans for edge transitions along rake lines inside the ROI. It then sorts the array of points to locate the tip. The search box can be resized to reference more or less of the edge and increasing accuracy adds more rake lines to sample.

The Tip tool is primarily used to generate a point for other tools. It also reports the distance measure of the tip referenced to the outside edge of the ROI.

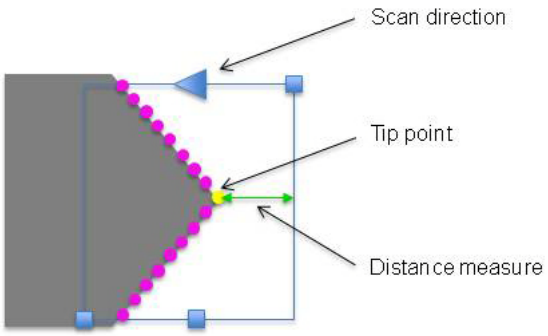
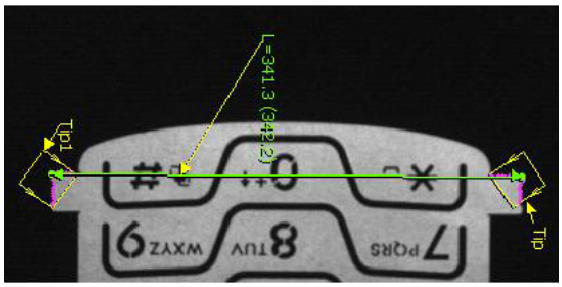


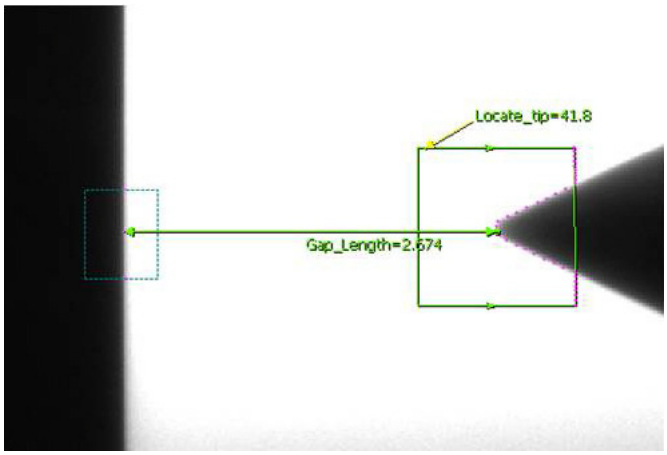
Table 1.6: Tip Tool Facts	
Supports ROI shapes	Rectangle
Tool creation	Click on any edge point
Accuracy	2 to 50 rake points within the ROI
Scan Direction	Selectable Dark-bright or bright-dark
Edge transition	Automatic with sensitivity slider

The Tip tool is often used to locate tip points for a distance measure as shown below.

Note! Using a Distance or Point tool to locate a tip or corner point will be unreliable as the rake points that define the best fit line will fall on either edge of the tip.



The example below is looking for the gap distance between the tip point on the right and the surface on the left.



1.1.7 The Caliper Tool

The Caliper tool is used to measure the distance between two extremities, like a real caliper. For example, the Caliper tool can be used to measure the width of a complex shape by scanning from the outside in, or the width of a gap by scanning inside out, or a combination of both.

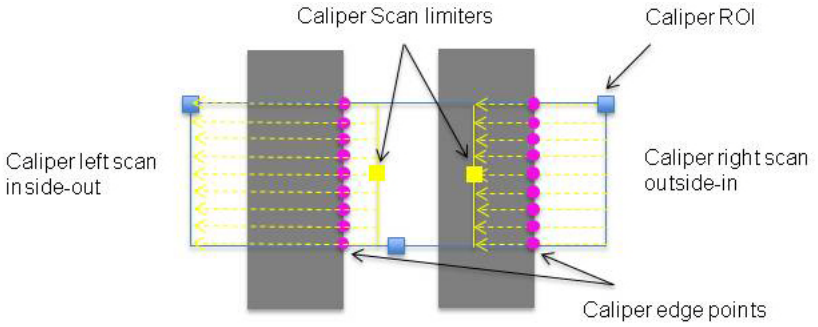
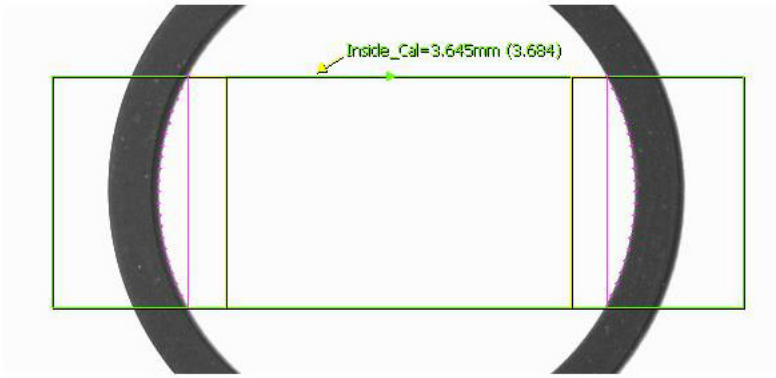


Table 1.7: Distance Tool Facts	
Supports ROI shapes	Rectangle with moveable scan limits
Tool creation	3 click points; left-right top and bottom
Measurements	Length
Scan direction	User defined in property page
Edge choice	Bright to dark or dark to bright
Edge transition	Automatic with sensitivity slider
Accuracy	2 to 50 rake points per side
Outlier support	No

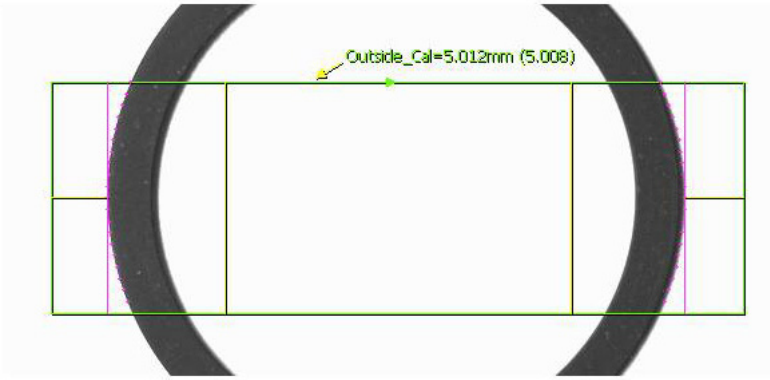
The scan limiters define the size of the scanning ROI on either side of the caliper. Each ROI is resizable by moving the yellow handle. If you move one of the scan limits all the way to one edge of the caliper ROI, the tool will perform a one-sided measurement.

For illustrative purposes, the following example shows the caliper being applied to measure the inside minimum and outside maximum distance between two arcs.

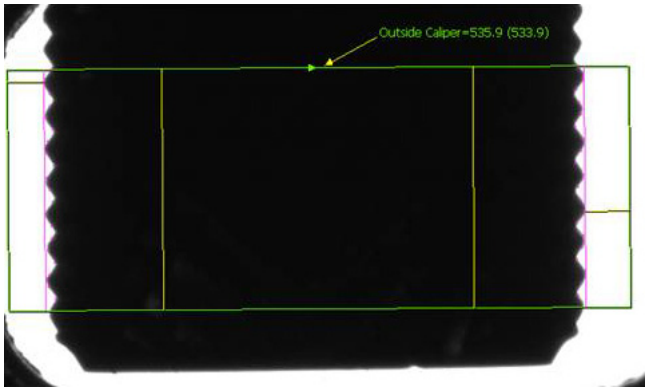


Above: Left and right limiters are set inside the arcs and each side is configured to scan inside-out looking for bright to dark edge transitions.

Below: Scan direction and edge type are reversed to measure outside caliper.



The following example applies a caliper tool to measure the distance between the left and right extreme points on a thread.



Below a caliper tool is applied to a preprocessed image of a cylindrical plastic container. The application is looking to make sure the ends of the container are installed and undamaged (which would be shown as a distorted end).

1.1.8 The Circle Tool

The Circle tool is used to measure the diameter and center position of a circle. The circle tool scans for edges along spokes inside an adjustable donut shaped ROI. Increasing the number of spokes improves accuracy of the measurement, at the cost of processing speed. The tool creates a “best fit” circle from the edge points to determine the diameter.

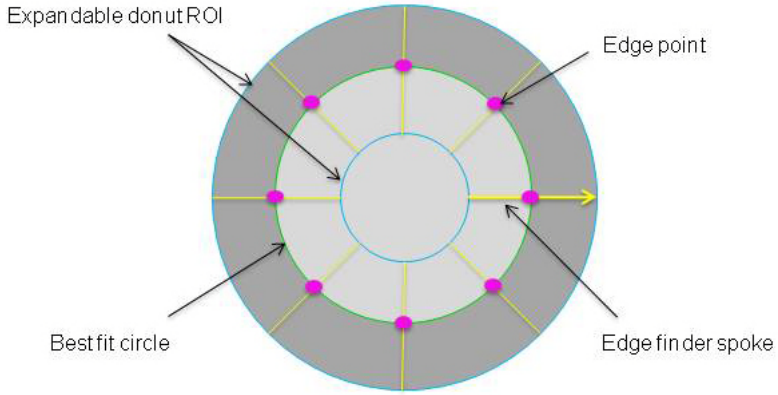
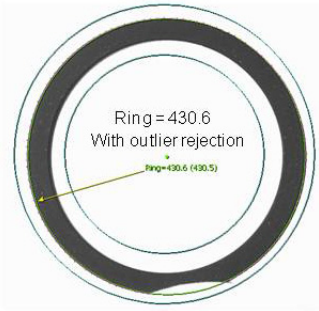


Table 1.8: Circle Tool Facts	
Supports ROI shapes	Circle (donut)
ROI creation	3 click points anywhere along circle edge
# of spokes	Up to 720
Scan direction	Fixed - Inside-Out
Edge choice	Strongest, First or Last
Edge transition	Dark-Bright, Bright-Dark, Either
Outlier support	Yes

The Circle tool can measure a circle accurately even when it is incomplete or damaged. This is done by using outlier rejection. In the bottom left picture, the cut-away section causes some edge points (the purple dots) to be included in the calculations of the circle, causing both the diameter and the center (the yellow dot) to be slightly off. By using a 20% outlier rejection parameter (bottom right picture), both the diameter and center are now correct.



1.1.9 The Concentric Circle Tool

The Concentric Circles tool is used to measure the concentricity of two circles. The concentricity measure is the maximum distance from either circle to the average position of the two circle centers. The Concentric Circles tool can also measure the widths at regular sampling intervals of the ring formed by the two circles.

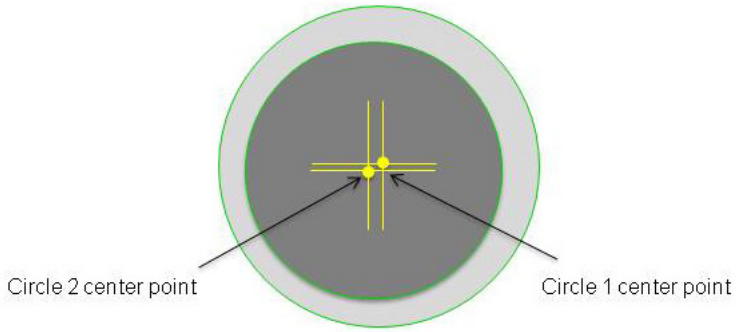
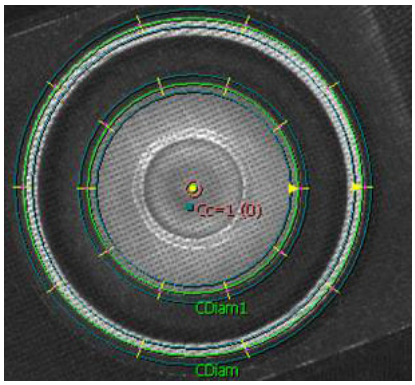
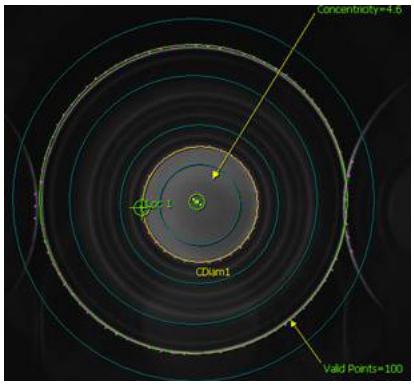


Table 1.9: Concentric Circle Tool Facts	
Supports ROI shapes	References 2 defined circle tools
Tool creation	1 click on each circle outline
Measures	Average, Min, Max and standard deviation between circle center positions

The examples below use the Concentric circle tool to verify that the inner and outer walls are correctly aligned. The right image is directly looking into a paint can moving toward a filling station. If the outer wall is damaged, the concentric measure will fail and the can will be discarded.





1.1.10 The Arc Tool

The Arc tool is a variant of the circle tool that is used to measure the radius and center position of an arc. Arcs with a larger angle will yield more accurate results. Unless it is necessary choose an arc that is at least 90°.

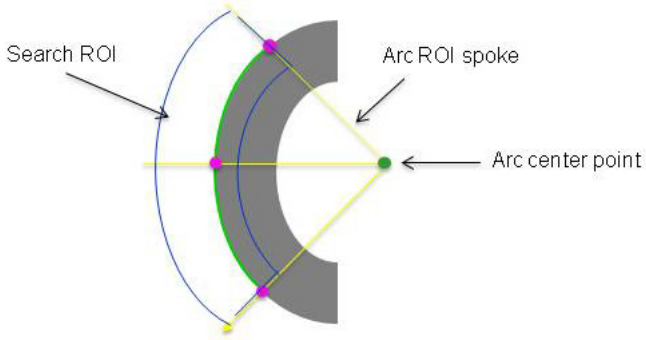
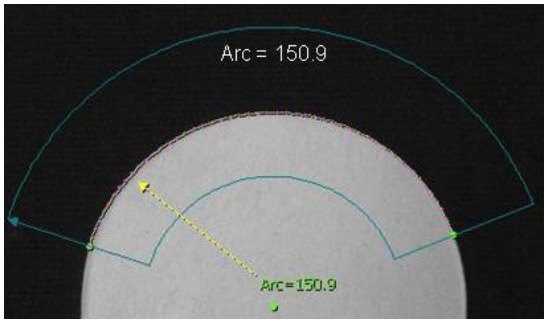
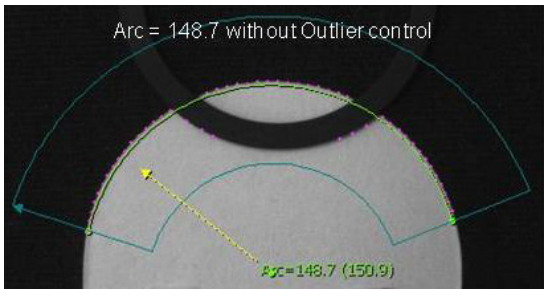
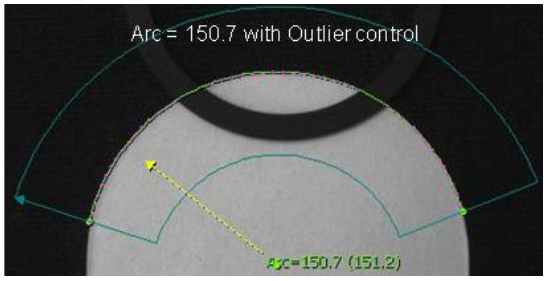


Table 1.10: Arc Tool Facts	
Supports ROI shapes	Arc (half donut)
ROI creation	3 click points anywhere along arc edge
# of spokes	Up to 72
Scan direction	Inside-Out
Edge choice	Strongest, First or Last
Edge Type	Dark-Bright, Bright-Dark, Either
Edge transition	Automatic with sensitivity threshold
Outlier support	Yes

As with the Circle tool, the outlier control in the Arc tool can be used to reject small defects along the arc edge as shown below:







1.1.11 The Edge Count Tool

The Edge Count tool is used to count how many edges a line runs across. It can also be used to measure the separation distance between each pair of edge points along the path. As such, the Edge Count tool can be used across a range of applications including simple presence/absence of features and precision measuring.

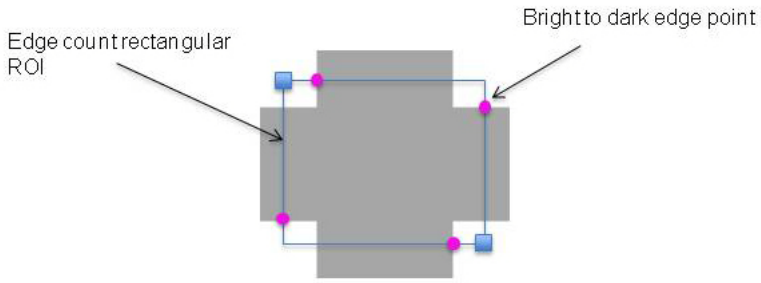
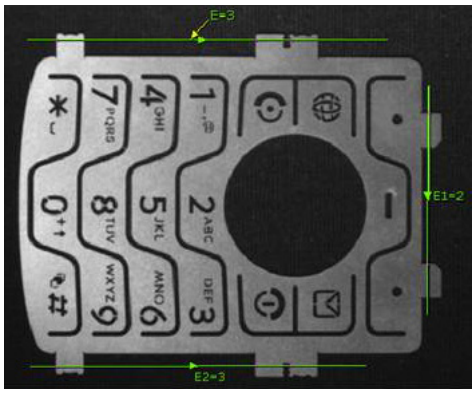


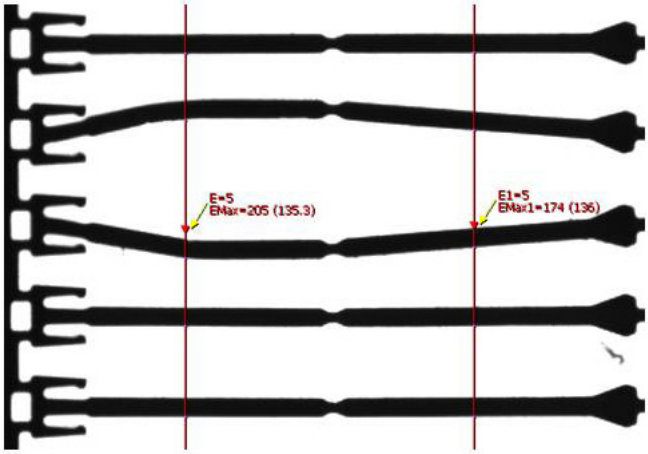
Table 1.11: Edge Count Tool Facts	
Supports ROI shapes	Line, rectangle, polyline, circle, arc
Tool Creation	Variable click points to create ROI shape
Measurements	Count, average, min, max point separation
Scan Direction	First to last click point
Edge Choice	Dark to bright, bright to dark, either
Edge transition	Automatic with sharpness and sensitivity control
Edge points	Passive (measure only) or active

The example below is simply looking for the assembly alignment tabs on a mobile phone keypad. This can be easily accomplished using line ROIs which would be aligned to a locator on the part (not shown).

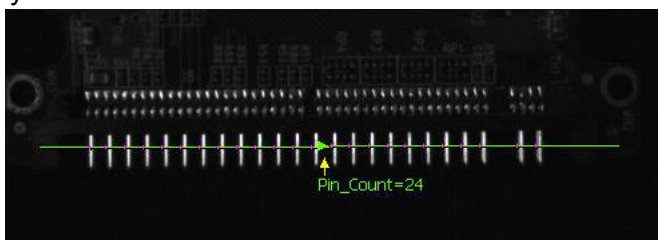


Similarly, the Edge tool can be used to look for edges that are not expected. In this application, an Edge tool is positioned above the cap. If no edges are detected, the cap is installed correctly.

The Edge Count tool can be used to measure the separation distance between each pair of edge points along the path. In the example below, the distance between each edge on a reel of electrical stamped pins is measured to look for deformation.

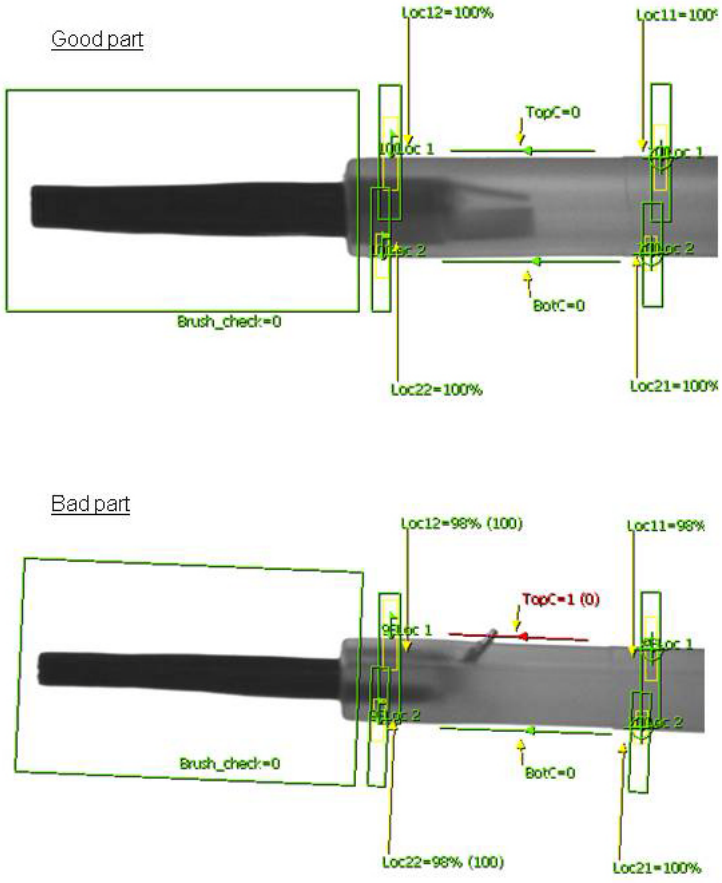


In the following application, the pins on a PCB connector are being counted to ensure that the assembly is correct.



In the following application the Edge count tool is being used to detect the presence of staple ends that have penetrated the outside of the brush handle.

Locators are used on either side of the handle to correctly align the Edge Tools with part movement.



1.1.12 The Contour Tool

The Contour tool is used to measure the consistency of an arbitrarily shaped contour (continuous edge). The tool traces an edge during setup and detects deviations at runtime by measuring edge point positions along each respective rake line. Missing edges indicate a discontinuity in the edge.

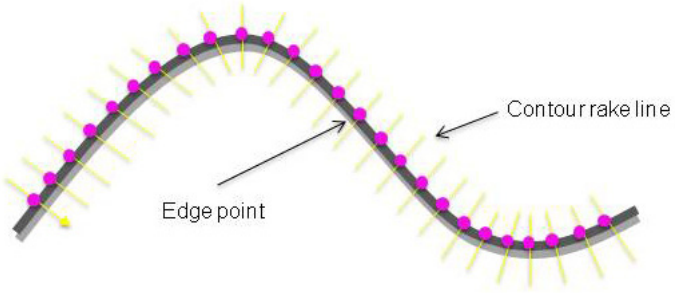
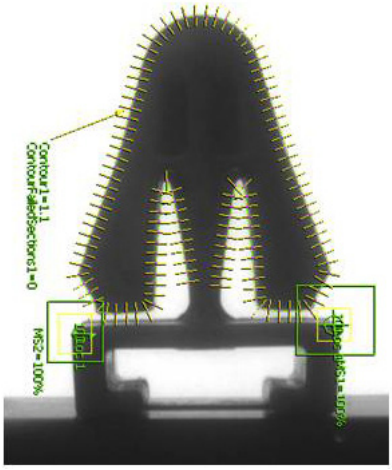
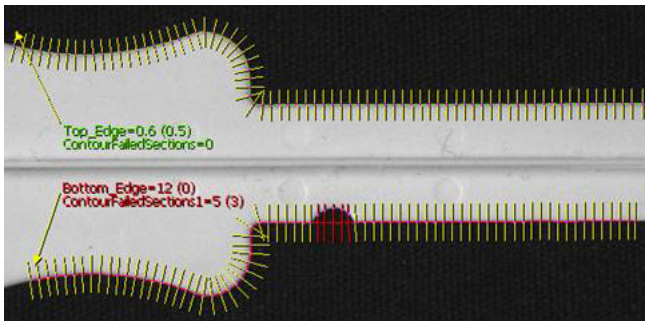


Table 1.12: Contour Tool Facts	
Supports ROI shapes	Automatic Edge trace
Tool Creation	2 clicks on start and ending contour points
Measurements	Deviation and failed sections
Scan Direction	Automatic
Edge Choice	Dark to bright or bright to dark
Edge transition	Automatic with sensitivity slider
Edge points	Passive (measure only) or active

The plastic parts below are typical applications where the contour of the part needs to be verified after the molding process. Any problems with the mold will be easily detected.



This image indicates failed sections where the edge points fell outside of the user tolerance due to an unexpected notch in the part. In some cases, some amount of deviation may be acceptable until a limit of consecutive “failed sections” are reached.



1.1.13 The Bead Tool

The Bead tool is used to measure the consistency of an arbitrarily shaped, fairly narrow line. The Bead tool can detect whether any sections are missing or too wide or too narrow, or whether the path deviates too much from the trained shape.

The bead tool defines equidistant rake lines along the bead. The length of each rake is determined by the bead's width. Each rake is scanned to detect the outside edges from which the center point is determined. A rake line fails if either of the edges are not found or the center or width of the bead deviates from the defined tolerance. At setup time, a rake line can be moved for fine alignment by clicking on it's center point and dragging it to a new position.

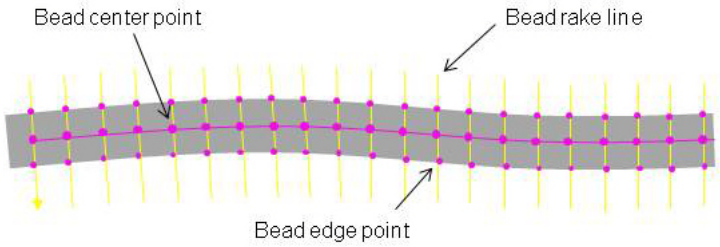
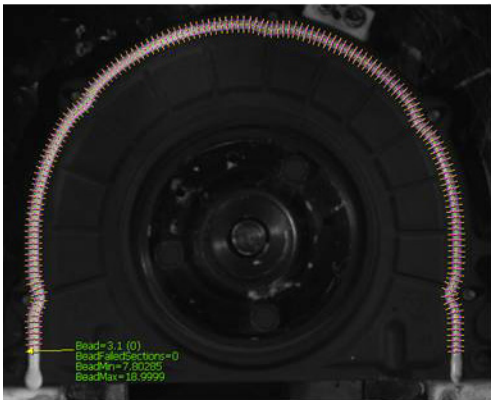


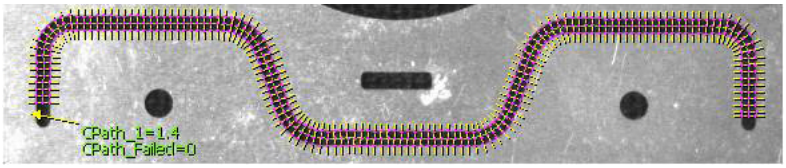
Table 1.13: Bead Tool Facts	
Supports ROI shapes	Automatic Edge trace
Tool Creation	2 clicks on start and ending contour points
Measurements	Deviation and failed sections
Scan Direction	Automatic
Edge Choice	Dark to bright or bright to dark
Edge transition	Automatic with sensitivity slider

The application below uses the bead tool to verify the integrity of a liquid gasket on an automotive assembly. The application is looking for discontinuities (breaks) and thickness irregularities.

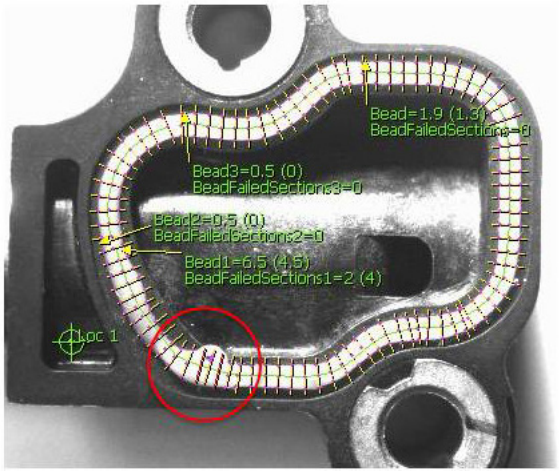
Note! The contrast of the bead to the background is quite good which is an important consideration when selecting the bead tool for applications.



The application below uses the bead tool to verify a feature in a stamped metal part. As long as the feature being inspected is continuous and uniform in width, the Bead tool can be applied.



The application below uses several bead tools to verify the integrity of a rubber gasket on a small automotive assembly. The use of multiple tools on a part like this is sometimes easier in order to make fine adjustments, especially where the contrast between the bead and the background is not optimal. The image highlights sections of the bead where the tool failed to located edge points within the defined tolerance.



Note! In some applications, small bead thickness variations are expected. In such cases, you can define how much variation is acceptable by defining the number of continuous rake lines that exceed or fall short of the nominal tolerance.

1.1.14 The Match Tool

The Match tool is used to locate one or more instances of a distinct pattern. The pattern can include all of the pixels in a region or just the edges. Because the Match tool can locate a distinct pattern easily, it is often used to create points that can be used as locators for alignment of other tools.

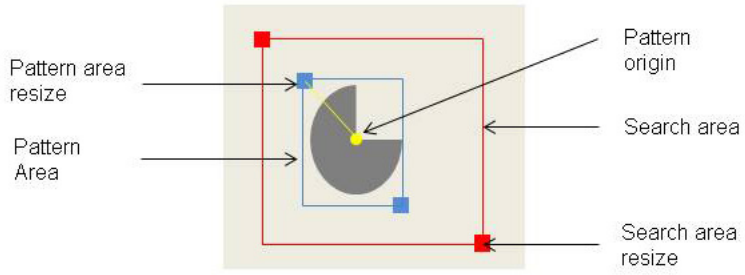
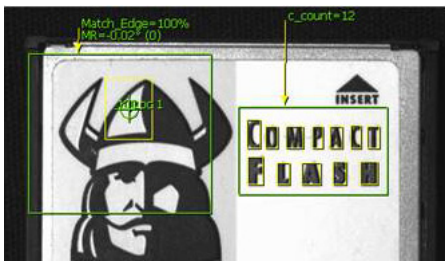
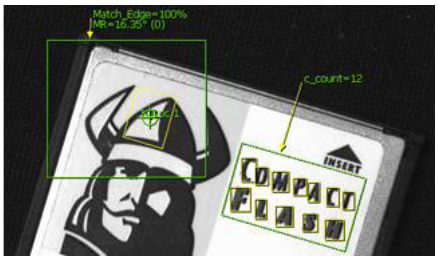


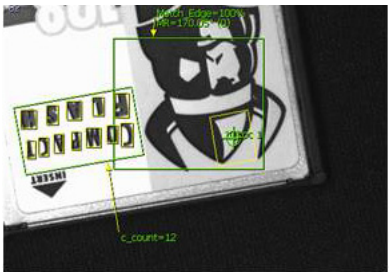
Table 1.14: Match Tool Facts	
Supports ROI shapes	Automatic Edge trace
Tool Creation	2 clicks on start and ending contour points
Search ROI	Resizable to cover part movement area
Patter ROI	Resizable to define feature within search ROI
Supported algorithm	Correlation (template match) or Edge
Match count	User defined
Match score	Defines accuracy of match (up to 100%)
Rotation	User defined (affects speed)
Accuracy	Sub-pixel
Speed optimization	Image sub-sampling for large features
Measurements	Deviation and failed sections

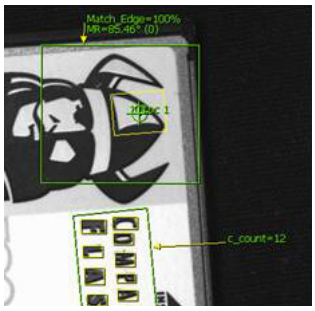
Image patterns that exhibit well defined edges can use edge or geometric matching. The “Edge” option is selectable in the Match tool property page. This method of pattern finding is more robust and more accurate than area based matching, but it is also slower in execution speed. Keep pattern and area ROI shapes as small as possible to achieve optimal performance.





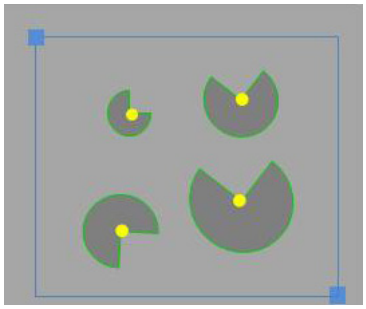
This example uses Edge based pattern matching to locate a distinct feature on the Viking's helmet. This feature can be quickly found in any orientation as long as the part rotates within the defined ROI. The center point of the match is used to align a Count tool that counts the number of characters on the part. The Count tool ROI rotates according to the output of the Match locator.





1.1.15 The Count Tool

The Count tool is used to count or verify blobs that are of a distinct brightness compared with the background. The tool can locate the center and corner (bounding box) points of blobs which can be used as locators, positional tracking or reference points for other tools.



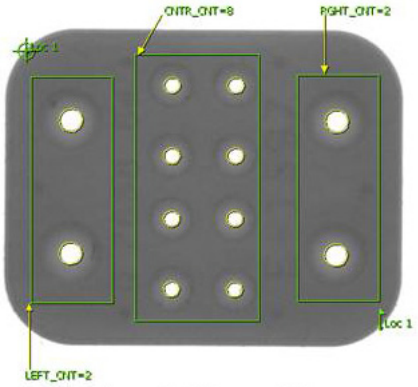
Rectangular count ROI showing found blobs with their center points

The Count tool provides interactive filtering to extract blobs of interest.

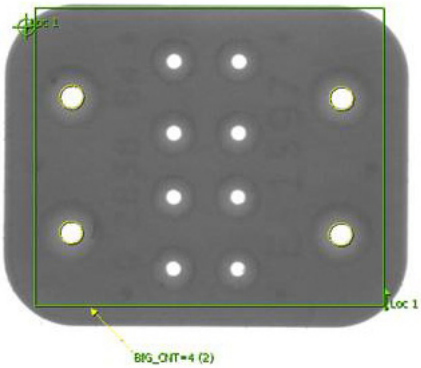
Table 1.15: Count Tool Facts	
Supports ROI shapes	Rectangle, polygon, circle, donut, ½ donut
Tool Creation	2 click points to define ROI size
Measurements	Count (total) - Area, Minor, Major, X ,Y (each)
Points	Center or corner of each bounding box
Blob Selection	Dark, bright or either
Background	Uniform or variable (light change across ROI)
Threshold	Interactive slider
Blob Filter	Area, Minor, Major, X, Y, First or All

The Count tool is quite flexible and can be used in a number of applications….

In this application the Count tool is used to verify the number and size of holes in a metal plate. One or multiple count ROIs can be applied to do the job. The image on the right shows how filtering can be applied to only find blobs of a certain size.

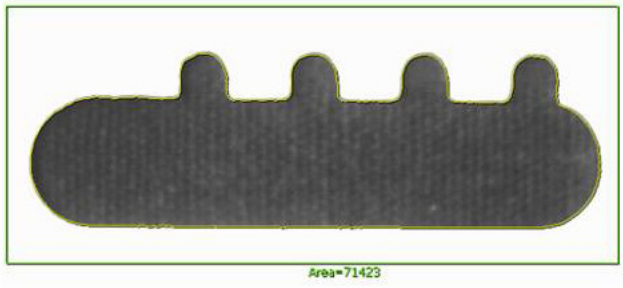


Hole verification on plate

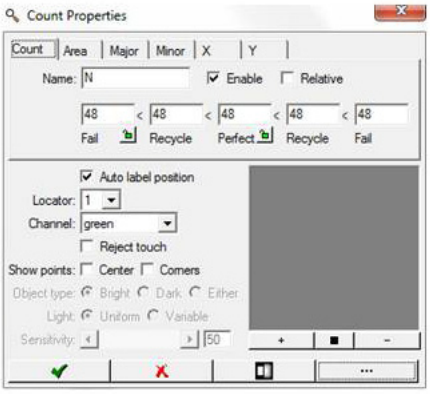


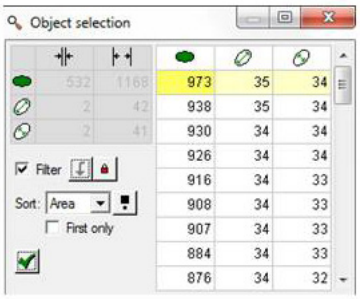
Hole size filtering

In this application below, the Count tool is used to return the area of a blob as a measure of connected pixels. This is useful for verification of arbitrary shaped objects.

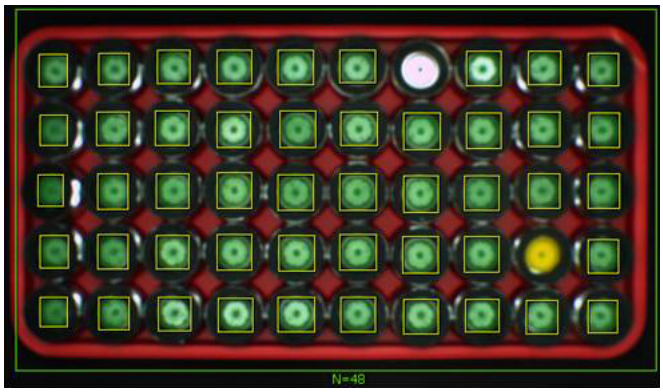


The Count tool can be applied to a segmented color image. The application below needs to count the number of green aerator heads in a packing crate. The filter capability of the Count tool is used to disregard any small area blobs that are not of interest.

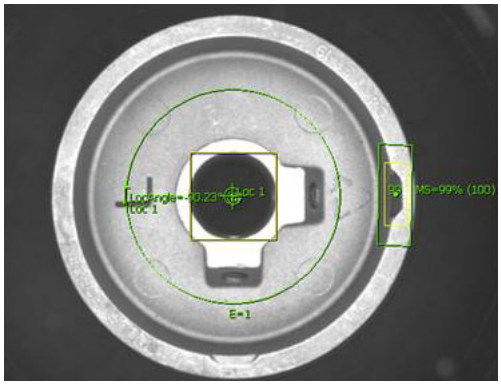


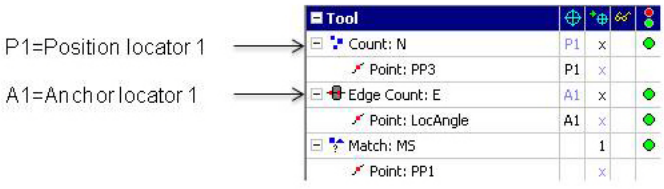


The Count Tool property pages above show the “green” color enabled with a minimum area filter setting to obtain a 48 object count. The runtime image is shown below.



This example shows how the Count tool can be combined with an Edge tool to create an effective 360° locator for alignment. The Count tool is used to find the X-Y position of the inside black blob. Since the blob is symmetric, it can not provide the rotational information needed to align a pattern Match tool used on the outside to verify the notch. However, this information can be obtained using an Edge tool with a circle ROI aligned to the positional locator. The Edge tool will detect the grayscale transition of the “L” character stamped on the part regardless of it’s orientation. The point of this edge transition can then be used as the rotation anchor of the locator. With the position and rotation anchors defined, the Match tool can be accurately positioned over the expected location of the notch.

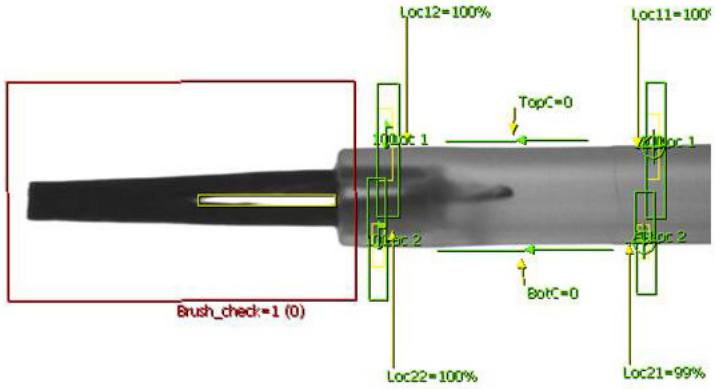




The Count tool can be used in conjunction with other tools. In this example the count tool locates the centers of the inner holes which are then used by a pencil tool to find the orientation of the part.

The Pencil tool connects the center points of the inner holes and returns the angle.

In the example below, the Count tool is used to look for bright holes in a cosmetic brush that indicate damaged or incorrectly assembled parts.



1.1.16 The Intensity Tool

The Intensity tool is used to measure statistical information of pixel values. It is often used in assembly applications to check for presence of features and similarly in final inspection to check for the absence of defects. Since the Intensity tool measures pixel values, care must be taken to control lighting variation during inspection.

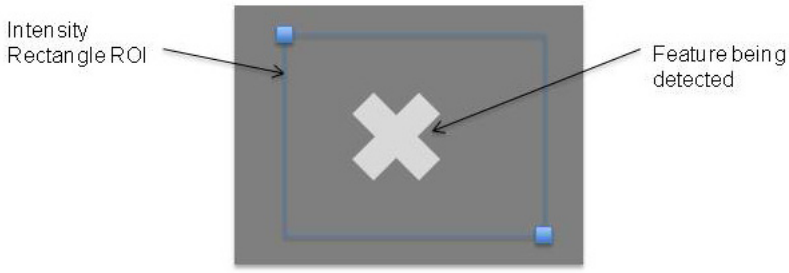
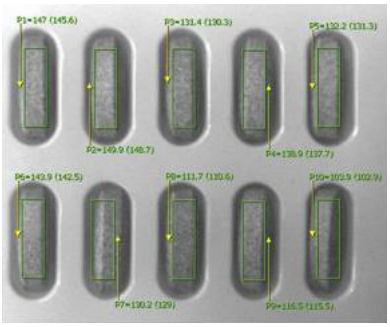
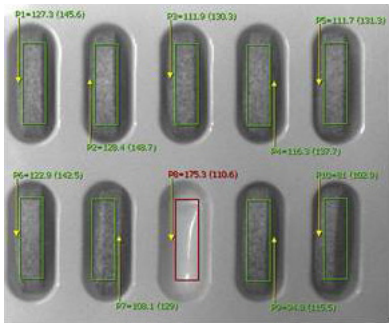


Table 1.16: Intensity Tool Facts	
Supports ROI shapes	Rectangle, polygon, circle, donut, ½ donut
Tool Creation	Variable click points to create ROI shape
Statistics	Average, min, max, std dev, mode, median
Limits	Pixel min and max count

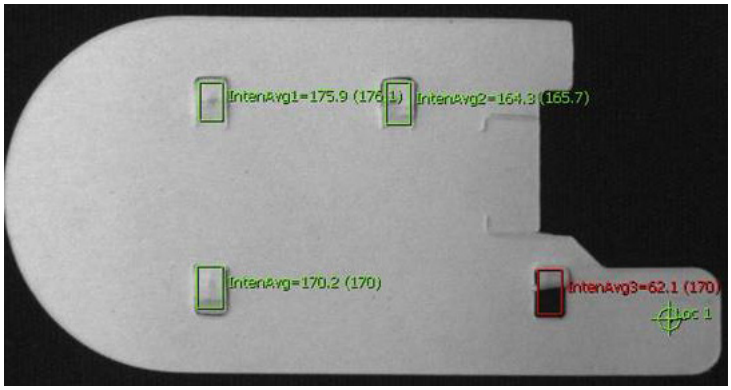
The Intensity tool returns the average pixel value of all pixels within the ROI. It also reports the minimum and maximum values, standard deviation, mode and median. The min/max values are often used to look for very dark or very bright defects, such as pin holes in a surface. The min/max count limiters are useful in some situations where you might want to mask the min/max values from the average result.

In this example, the gap between average pixel values are used to determine if a pill is present in the package. The pixel values vary by 50 gray levels under controlled lighting which is easily enough to render a reliable result.

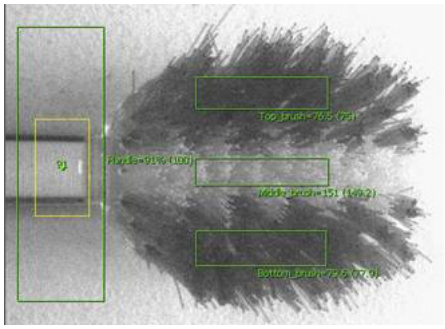




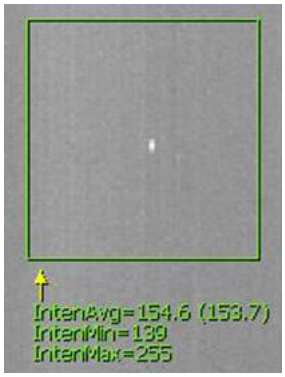
Similarly, the example below shows the intensity tool is being used to verify that the assembly tabs on a plastic part are closed. In this case, one of the tabs is damaged and the part is rejected before moving to the next stage of the process.

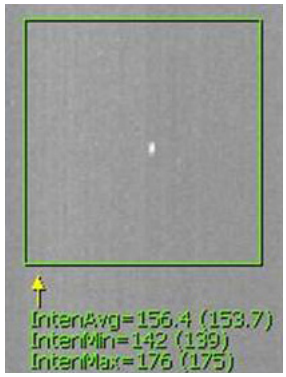


A similar example shows how the intensity tool is being used to verify brush parts on a toothbrush head. This application is looking for gross defects where one side or the middle of the brush is missing.



The example below shows how the bright spot in the middle of an extruded plastic part can be eliminated from the average intensity calculation by using the max count limiter. In this case, the 9 brightest pixels associated with the spot are discarded by setting the max count limit to 10.





1.1.17 The Color Meter Tool

The Color Meter tool is primarily used to determine the color of an area. It uses the color classes assigned by the Inspector Color setup utility. It is often used for spot checking an assembly or package for color correctness. A typical example would be to verify the correct fuses (color coded) are installed in an automotive fuse box.

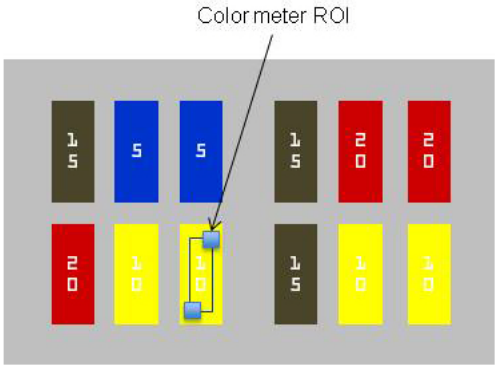
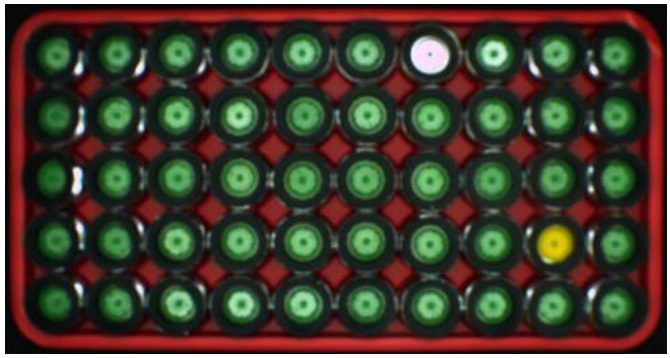
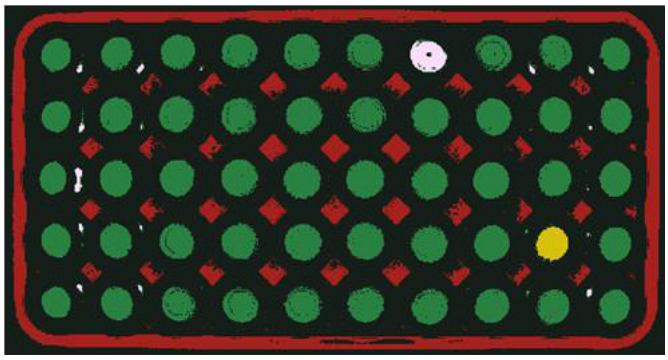


Table 1.17: Color Meter Tool Facts	
Supports ROI shapes	Rectangle
Tool Creation	2 click points to form rectangle
Measurements	Main 3 colors in ROI with % of each + RGB average value.

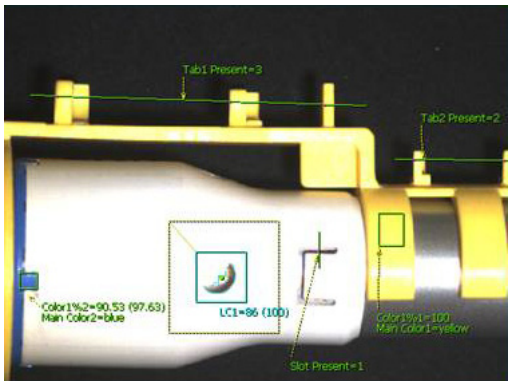
Instead of reporting the exact RGB value of a color, which can fluctuate significantly depending on lighting and sensor variability, Inspector groups colors into a small number of classes. To illustrate, look at the first image below. We can group the colors in this image into 5 classes: Red, Green, Blue, Yellow and Background (everything else). Each class can include multiple shades of the same color, so every pixel in the image is assigned to a class.



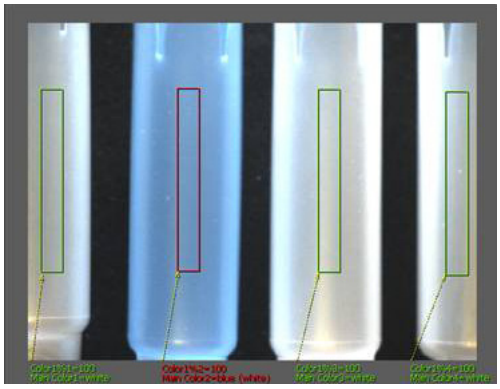
With the image segmented, the Color meter tool can easily report the 3 main colors that occupy the ROI along with the density of each.



Some more examples using color. The first application is verifying the correct assembly of a medical instrument. This application uses a combination of color meter and edge count tools.



The application below is simply checking the color on some plastic parts to ensure correct packaging. In this case the blue part is expected to be white and the inspection fails.

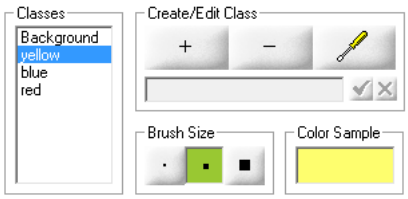


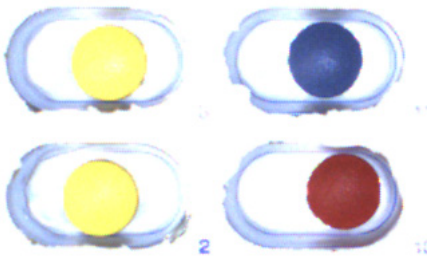
1.1.17.1 About Color Training

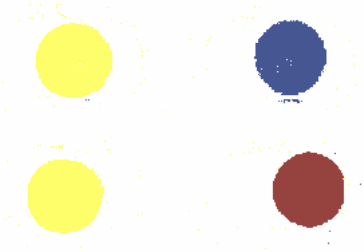
Traditional color classifiers operate on region based models. These classifiers calculate a cuboid or sphere based on trained colors. So they only allow a few trained colors, which in turn means those colors must be carefully chosen. With the color classifier in iNspect, you don't worry about having too many trained colors, you can drag the mouse around and train tens or hundreds of pixels in a single stroke. This means you can define multiple shades of the same color easily or even classify completely different colors into the same group (i.e. Apple = green or red, Orange = orange, Lemon = yellow etc).

After training, Inspector will assign every pixel in the image to a class. So, if there are 5 colors in the image and you only train 3 of them, Inspector will attach the 2 untrained colors to the "background" class. The key is in the training. The more colors you train, the easier it becomes to segment pixels.

If you make a mistake during training and accidentally train the wrong color, you simply train over it with the right color. For example, let's say you pointed to a green pixel and accidentally trained it as red. Instead of undoing, just hit the same pixel again and train it as green. In fact, this training overwrite is what enables the classifier to make very accurate partitions of the color space. With practice you can train and re-train hundreds of sample pixels in a couple of minutes.







Example color trainer. Here we define 3 colors to classify pills in the right top image. Colors around the pills associated with the packaging are trained in the background class.

1.1.18 The Barcode Tool

The Barcode tool is used to read a variety of linear barcodes for product verification and tracking. 1D barcodes are commonly used on all kinds of consumer level packages. They generally store less information than their 2D counterparts, but they are easy to print and often easy to read with low-cost laser scanners. Many industrial applications combine the barcode tool with other tools as part of final package verification.

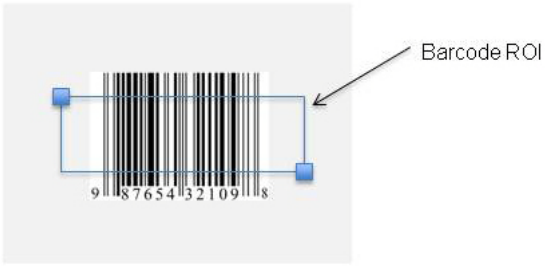
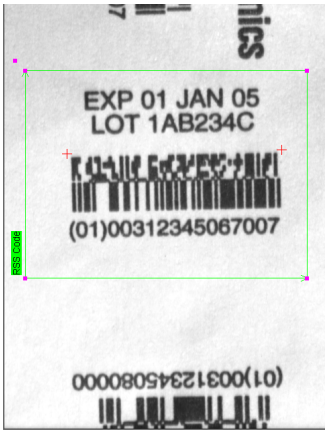


Table 1.18: Barcode Tool Facts	
Supports ROI shapes	Rectangle
Tool Creation	2 click points to form rectangle
Supported types	UPCa, UPCe, EAN8, EAN13, Code39, Code93, Code128, ITF, codabar, BC412, Pharmacode, Postnet, Panet, Onecode, GS1
Grading	Yes
Fielding	Ignore positions and/or characters
Contrast	Black on white or white on black
Orientation	Automatic or manual (for speed)

The Barcode tool is used to read a variety of linear barcode types, such as UPC, ITF and RSS (GS1):


Bar=XC5C168AYA300041900
2061-701532-000 AJ XC 5C16 8AYA 3 0004190 0194
2060-701532-000
REV A
E54


0 72125 00089 0
UPCa Barcode=072125000890
Lot Code=EXP.04 04 29117
EXP.04 04 29117


EXP 01 JAN 05
LOT 1AB234C
(01)00312345067007
RSS GS1


050428247235
0 50428 24723 5
UPC PRODUCT CODE

1.1.19 The 2D Matrix Tool

The 2D Matrix tool is used to read 2D Matrix codes for product verification and tracking. Matrix codes use graphical patterns for encoding characters and numbers. Unlike 1D barcodes, 2D symbols can store a lot of information in a very small footprint. Each code consists of a finder pattern for locating the symbol and its orientation in an image, a data pattern consisting of binary cells grouped relative to the finder pattern and a quiet zone to distinguish the finder pattern from the background.

2D symbols are printed with a variety of direct part marking (DPM) techniques on almost any type of surface. Poor quality and consistency of printed codes can make decoding difficult or even impossible. The use of image preprocessors and model training can be combined with the 2D Matrix Tool to improve read rates and robustness in these cases.

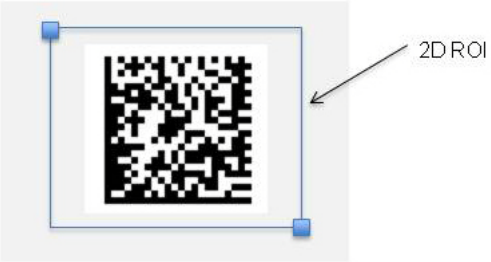
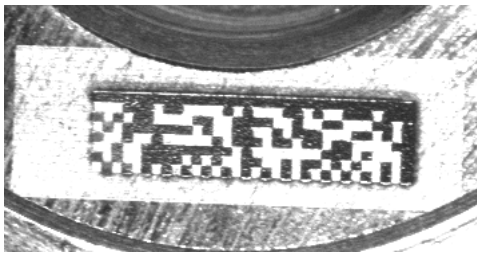
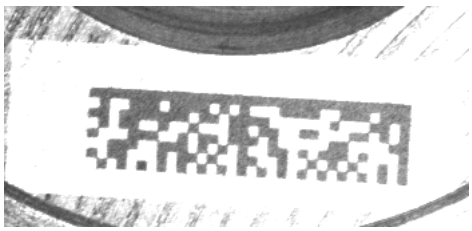


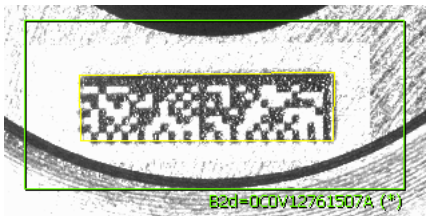
Table 1.19: 2D Matrix Tool Facts	
Supports ROI shapes	Rectangle
Tool Creation	2 click points
Supported types	DataMatrix, QR code, Micro QR, PDF417
Grading	ISO16022, ISO15415, AIM DPS, AS 9132
Fielding	Ignore positions and/or characters
Contrast	Black on white or white on black
Orientation	Automatic or manual (for speed)
Training	Integrated for DataMatrix

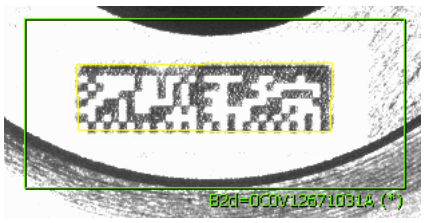
The example below demonstrates variation that can be seen between parts on the production floor. In this case the codes are laser printed on metallic surfaces. As the parts navigate through assembly process they are vulnerable to oil spills which can dramatically degrade the code quality. The image on the left has poorly defined alignment bars and a noisy quite zone, whereas the image on the right is close to ideal.



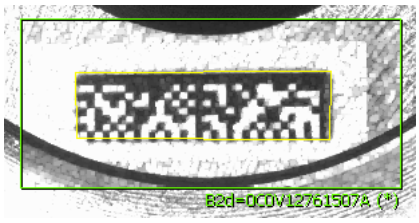


Noisy, poorly defined code	Clean, well defined code





The 2D Matrix tool offers model training and preprocessors that can be applied in cases like this to improve read robustness. The above images are read successfully after model training and below see how the quality of the same images can be improved by applying the “erode” and “dilate” preprocessors.



This example shows a 2D Matrix printed inside a circle. Even though the code looks clean, the circle makes the code difficult to read by interfering with the quiet zone, thus making it difficult to determine orientation. Like the previous example, this can be overcome by applying model training at setup time. Training allows the user to define the code boundary so that the quiet zone can be ignored. At runtime the tool will search for the trained model and report it’s orientation to the reader algorithm.

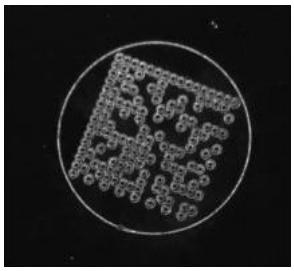
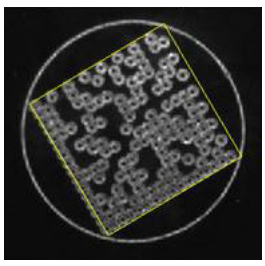
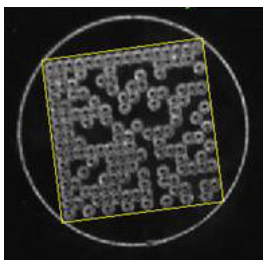
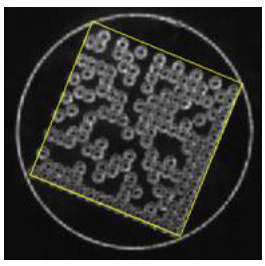


Figure 1.1 Circle interfering with quiet zone

Examples of runtime images are shown below. If the use of the model trainer alone is not enough to satisfy all cases, the next step would be to try and remove or reduce the circle affect by applying image preprocessors. It should be noted of course that preprocessors apply to the entire ROI equally which will alter the print quality of the code.







1.1.20 The OCR Tool

The OCR tool is used to read and verify printed characters or symbols. A typical applications for the OCR tool is to verify date and lot codes on product packages, but It can also be used to identify and classify parts by printed features. The OCR tool is designed to tolerate lighting variation and highly damaged or noisy images which are commonly found with printing on metallic, plastic or textured surfaces.

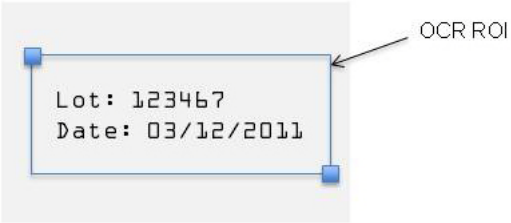
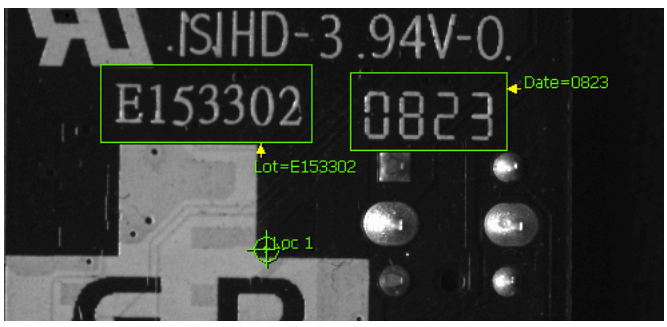


Table 1.20: OCR Tool Facts	
Supports ROI shapes	Rectangle (normal/rotated), donut, ½ donut
Tool Creation	Variable click points to create ROI shape
Output	Character string and quality (min, max, mean score against trained character)
Algorithms	**Binary** (high quality, high contrast character separation), **Grayscale** (lower quality, les contrast separation).
Font training	Auto detect or manual, gray level sensitivity slider, add/ delete fonts
Performance	5 speed grades or effort levels, image sub-sampling (for very large characters) and character count limit (early exit)
Fielding	By position and type
Quality	Minimum character score

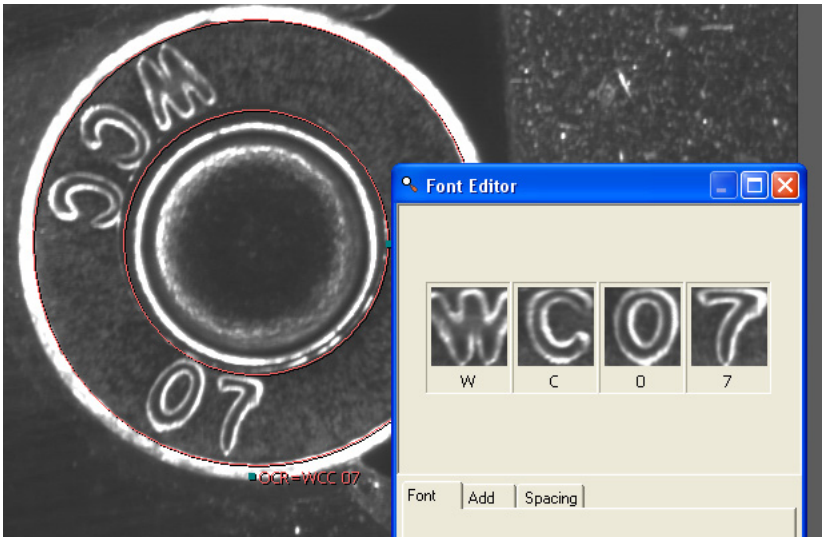
This simple example illustrates typical usage of the OCR tool to read and verify characters on a printed circuit board.

Note! In this case the font types of the two strings are different. Each font type is taught at training time and stored in the same or different font libraries (user preference).

The OCR ROIs in this example are aligned to the Match tool locator designated “Loc 1”.



A more challenging application is to read the identification characters printed on the object below. In this case the donut ROI is used to unwrap the character string. If the starting point of the text inside the ROI varies from image to image, the OCR tool can detect the longest string and always report the result with the longest string first. For example, in the image below OCR will always report the result as “WCC 07”, instead of “07 WCC” or any other order.

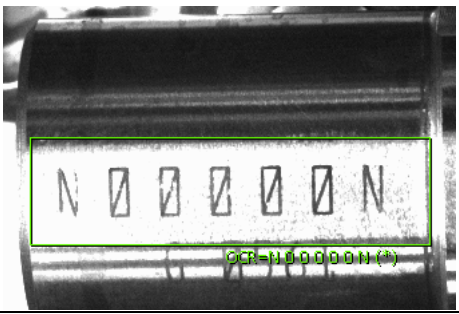


The example below shows typical lighting and print variation on metal parts as they move through production.

Saturated background

Varying background

Darker background



Faint characters

The variation in this application is not a problem for the OCR tool as the characters are fairly easy to distinguish under all conditions, but this is not always the case. For example. when you have characters that are very similar, like “3” and “8”, variation in background or printing can make character recognition quite challenging. In such cases training multiple variations of the font (good and poor printing) can help. At runtime the OCR tool will compare what it thinks is a character against all models stored in the font library to find the best match.

1.1.21 The Spring Tool

The Spring tool is a specialty tool used to measure length, pitch and diameter (width) of a spring or any wave like object. The Spring tool works like the Caliper tool in that it detects the peaks of each coil and then fits lines between the peaks to calculate the average measurements. The minimum and maximum position of the peaks are reported along with the standard deviation of all peaks.

The tip (peak) positions of each of the coils along with the fitted Pencil tools on either side of the spring and center are available to use with other tools.

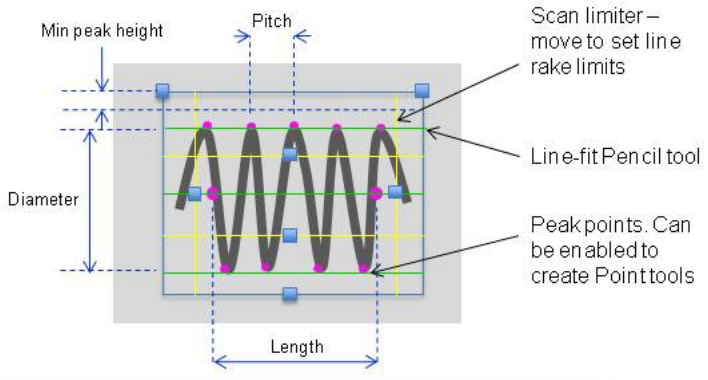
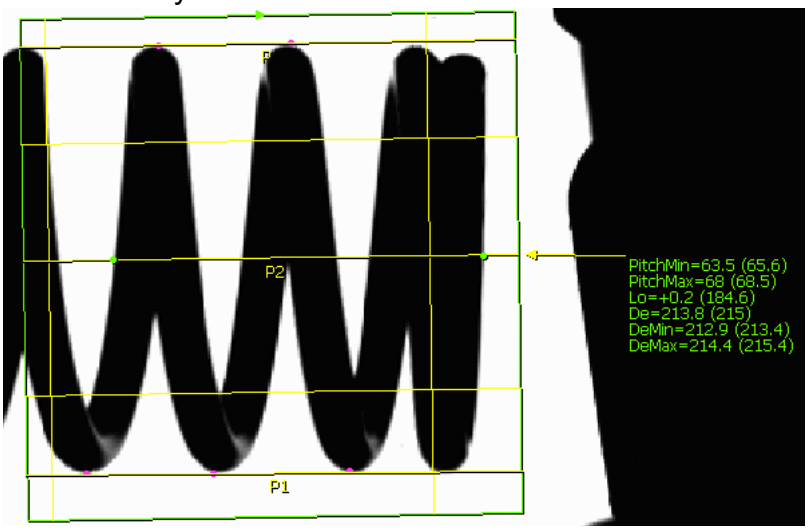


Table 1.21: Spring Tool Facts	
Supports ROI shapes	Rectangle with moveable scan limits
Tool Creation	Click 3 points to create ROI shape
Measurements	Length, pitch (with min, max, std dev) and width (with min, max and std dev)
Scan direction	Outside in (ROI border to scan limiter)
Edge choice	Dark to bright
Edge transition	Automatic with sensitivity slider
Peak detection	Closest points to ROI border greater than min peak height
Length measure	Point to point along center (moveable) axis

The Spring tool is used by a multi-axis bending machine. As the spring is being formed, machine adjustments can be made dynamically based on feed-back from the vision system.



Preprocessors can be used to enhance certain aspects of an image before a tool is applied. By applying one or more preprocessing steps, features that are difficult or impossible to measure can become easy.

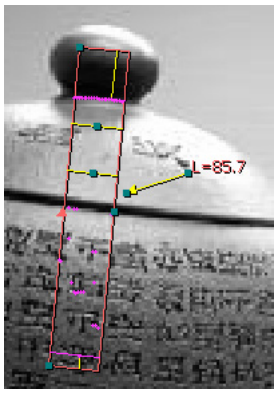
1.1.22 Pre-processors

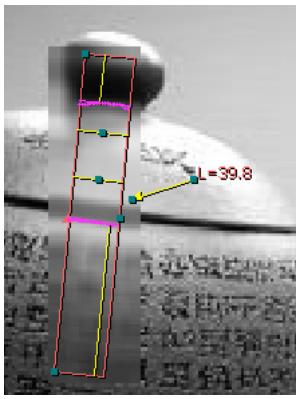
1.1.22.1 Low-pass

A low-pass operation has a smoothing or blurring effect on an image. It is so named because it only allows low frequency variations to pass through. It is useful for removing closely spaced intensity irregularities caused by electronic noise in the camera or texture variations on the actual object being inspected.

Consider the example below. A Caliper tool is used to find the distance between the top and bottom of a teapot lid. If we apply the tool to the left image, the Caliper fails due to the printing on the side (i.e. it detects high frequency edges that are not important in the measurement). To the algorithm, the printing appears essentially as random spaced noise. Applying the low pass filter operation results in the image on the right. The Caliper tool can now easily detect the edges to measure.

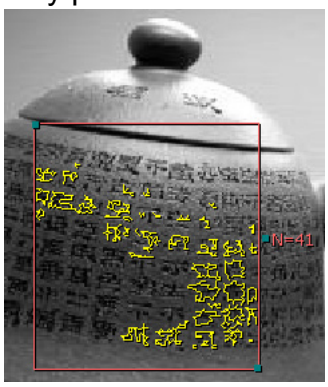
Note! If this application were real, we would have to consider the offset from the actual position due to the filter. This offset would be consistent from sample to sample.

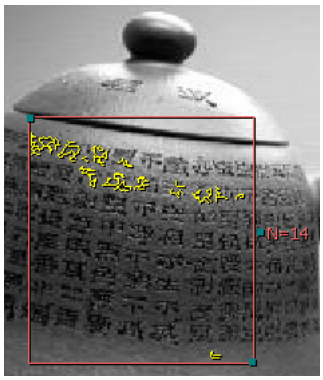




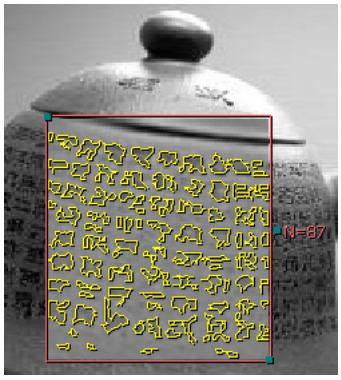
1.1.22.2 High-pass

A high-pass operation removes the effect of slowly changing intensity across an image. It is so named because it only allows high frequency variations to pass through.
In the example below, because of the curvature of the teapot and the uneven lighting, it is very difficult to pick out all the printed characters from the background when using a Count tool. Changing the sensitivity of the Count tool only picks out different portions of the teapot.



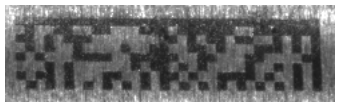


By running a high-pass operation, all the characters can be picked out.



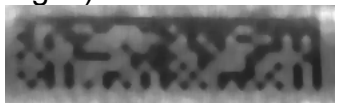
1.1.22.3 Median

The median operation replaces a pixel with the median (average) value of its neighborhood. It is similar to the low-pass operator in that it smooths an image. It is better than low-pass for removing spike like noise, sometimes called salt-and-pepper noise. Following is an example:
Original:



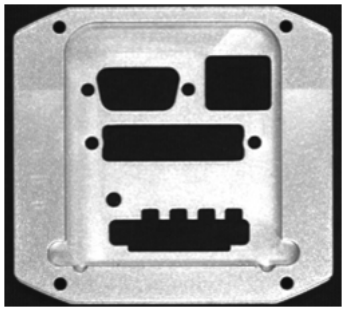
Low-pass (background texture is suppressed, but edges become blurry):

Median (note the sharper edges):

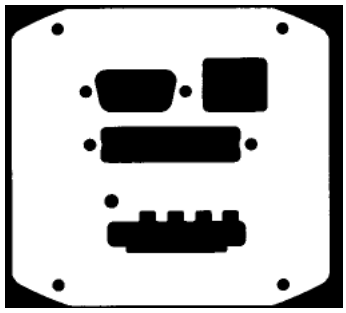


1.1.22.4 Threshold

The threshold operator turns a grayscale image into a binary image. Pixels above a threshold value become white, while those below the threshold become black.



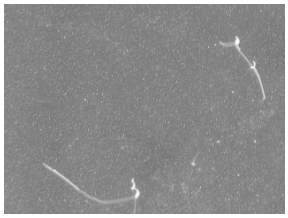
Original Image



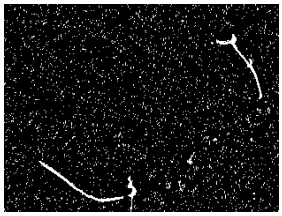
Threshold image
(faint variations are removed)

1.1.22.5 Adaptive Threshold

The Adaptive Threshold operator is the same as a high-pass operator followed by a threshold operator.



Original Image

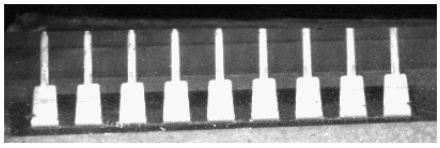


Adaptive threshold

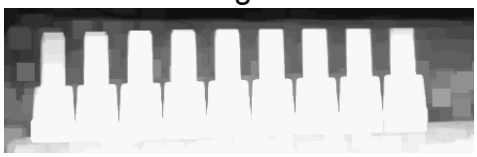
After median filter

1.1.22.6 Dilate

The dilate operator expands the brighter pixels. It is useful for grouping together small features that are lighter than their surroundings.



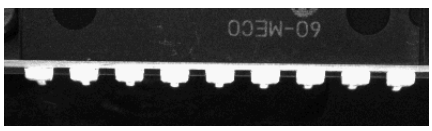
Original Image



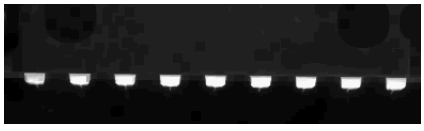
Dilated Image
(pins all grouped together)

1.1.22.7 Erode

Erode is the opposite of dilate. It expands the darker pixels. It is useful for breaking up features that are connected by a relatively thin segment.

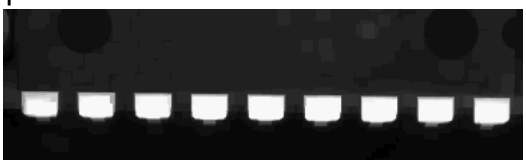


Original Image



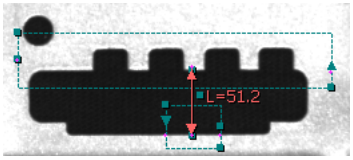
Eroded Image
(pins now separate and smaller

In order to maintain the size of the features after an erode operation, a dilate operation can be applied:

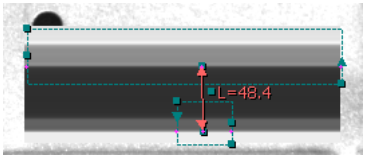


1.1.22.8 Project H

The project H operator replaces each pixel by the average pixel value of the horizontal line the pixel is on. It can be useful for ignoring smaller variations in the vertical direction.



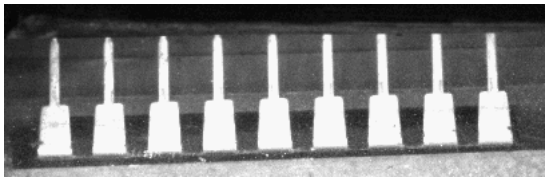
Original Image



Project H image
(small vertical protrusions are ignored)

1.1.22.9 Project V

Project V is similar to Project H, except that the projection is performed in the vertical direction.



Original Image

Project V image
(pins all grouped together)

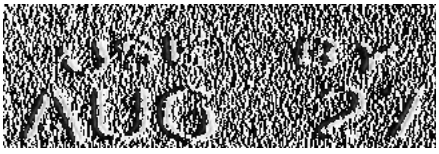
1.1.22.10 Convolve

The Convolve operator is the fundamental neighborhood operator that other operators such as low-pass and high-pass are based on. You need a good understanding of image processing science in order to use it effectively. Following is an example of using Convolve to perform directional edge enhancement:

Kernel

-1	0	1
-1	0	1
-1	0	1

Original Image



Convolved Image

Appendix A

Glossary

A.1 Terminology

Term	Definition
ROI	Region Of Interest. Defined as the area in which a tool inspects. Allowable ROI shapes are defined by the tool using it.
Calibration	The process of transforming pixel coordinates of the rendered image into real world coordinates of the object being imaged.
Edge	An edge is defined as the boundary between contrasting gray scale values in an image. Inspector tools process edge transitions based on their direction (light-dark or dark to light) and strength (rate of change). Edge detection is widely used for measuring, locating, counting and determining the presence or absence of features. Edge based tools can detect features much faster than pattern based tools.
Blob	Blobs refer to similarly shaded groups of connected pixels of arbitrary shapes. The process of extracting these blobs from an image and sorting them based on specific criteria is called blob analysis. This method is used by the Count tool.
Match	The process of matching a pattern against a trained template. The template pattern can be matched based on its area (a process referred to as correlation) or on its edges. Pattern matching is used extensively in machine vision for locating and sorting features.
Locator	The process of using a pattern or a feature within an image to align other tools. Locating is necessary to compensate for part movement during the production process. In Inspector locators are defined from points generated by pattern matching (Match) or Edge finding (point, Tip, Edge….) tools. Depending on which tools are used for locating, one of more points may be required to compensate for XY position and rotational variation.
Alignment	The process of aligning tools with the location of a trained pattern or feature. Alignment is required to overcome normal part movement during production. A locator tracks the part as It moves and provides coordinates to each of the aligned tools so that they can reposition their ROIs.

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