Sherlock 7 Technical Resource

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Industrial Products

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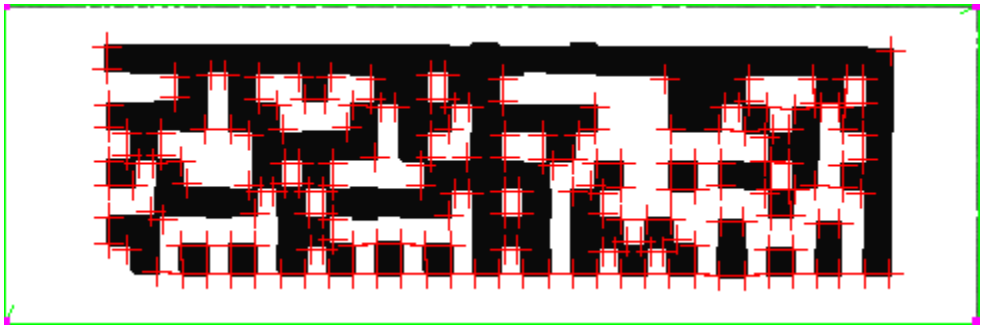
Corner Finder Algorithm

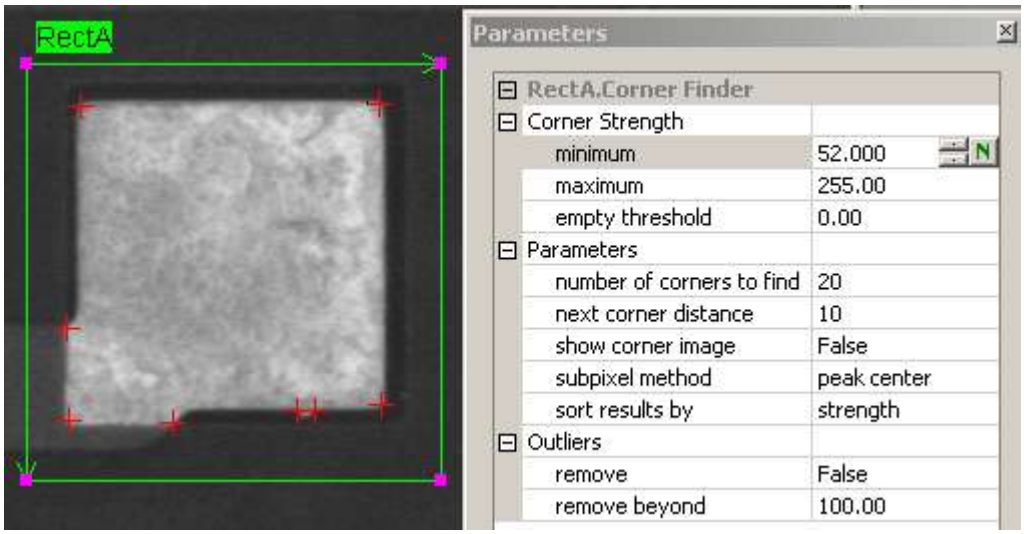


An image of corners found on a back-illuminated, metal-on-glass part. The ***subpixel method*** parameter was set to "peak center" because the "search" method finds corner positions between actual corners.

Corner Finder [algorithm]

Sherlock's "Corner Finder" algorithm, finds corners in an image. A corner is an image area bounded by two edges that meet at approximately a right angle. This area can be lighter or darker than its background.

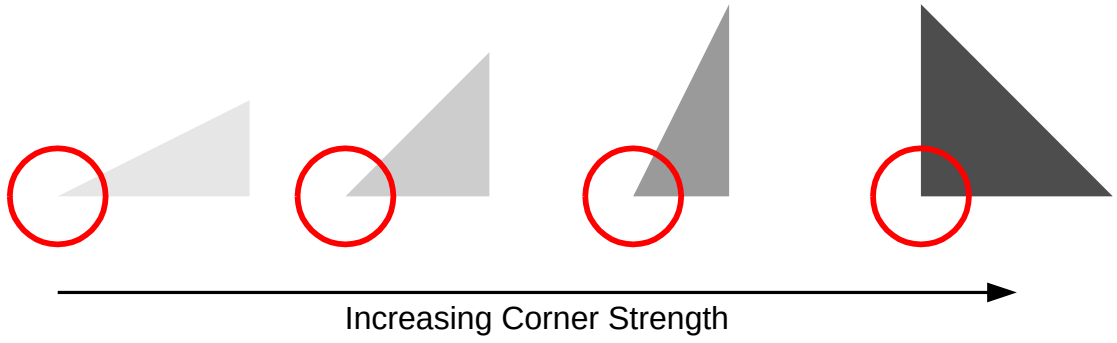
Corner location is used to find the position and orientation of parts, check for defects (missing or incorrect corners), inspect bolt threads and other periodic structures, etc. Here is an image of a printed circuit board (PCB) bonding pad with the corners marked:



A corner's strength increases:

- With higher corner-to-background contrast
- As the angle between a corner's edges approaches 90 degrees.

This drawing shows an increase in corner strength due to higher contrast with the background and corner edges approaching a right angle. Corners are circled in red:



Corner strength can have a very large range, perhaps as large as 400,000. To make it easier to set thresholds on the ***minimum*** and ***maximum*** corner strength, we normalize the strength to be in the range of 0 to 255. However, the ***empty threshold*** and parameter and the ***max response*** output are not normalized because you want an absolute rather than a relative measure.

Corner Strength Parameters

Adjust the *Corner Strength* parameters to help select the corners you want. The ***minimum*** threshold sets a minimum strength for detecting a corner, normalized to the range of 0 to 255. The ***maximum*** threshold sets a maximum strength for detecting corners. Setting this parameter to 255 disables it. The ***maximum*** parameter is useful when you have strong corners that you wish to suppress so you can detect corners with lower corner strength.

The ***empty threshold*** is applied to corner strength values without normalization. When all corners in the ROI are below this threshold, then all corners are discarded. Setting this parameter to 0 disables its use. This parameter is used to suppress reporting corners when the ROI is empty or just has noise, so it can be used to reduce "false alarms". For example, if we are detecting a part by its corners and the part is on a conveyer belt with some texture, you might get some false alarms when only the conveyer belt is in the ROI. Using the ***empty threshold*** parameter you can suppress these false alarms. When the part appears, its corners should be much stronger and so the normalization process will then suppress any low-contrast false alarm corners from the conveyer belt. The ***max response*** output is useful for setting this parameter.

General Parameters

Number of corners to find sets the maximum number of corners to find. Only corners that meet the ***minimum***, ***maximum, empty threshold*** and ***next corner distance*** requirements are found. In the first image (the IC bond pad), up to 20 corners could be found but only 8 meet these requirements.

After a corner is found, the next corner must be at least ***next corner distance*** away to be found. This prevents corners that are close to each other from being reported. It also helps prevent corners due to noise from being reported. For example, if ***next corner distance*** is reduced in the bonding pad example, then multiple corners are found at nearly the same location near some corners. These additional corners are due to image noise.

If ***show corner image*** is true, the corner strength image is output and displayed. The stronger a corner is, the brighter the spot in the output. To better see the corner image, you can disable the default annotation (the red + marks at each found corner) by double left clicking the "corner points" output and setting "Display in image window" to "[None]". This parameter is used for setting up and debugging an Investigation, and should be set to false when you are running to save processing time.

The corner detector in "Corner Finder" is fast but has limited accuracy. The ***subpixel method*** parameter selects additional processing that improves the accuracy of the corner detector but takes more computation time. This parameter can be:

- None. No subpixel accuracy improvement is applied to corners
- Peak Center. The center of the peak corner strength is found (the default)
- Search. Search for the best corner position near the corner strength peak.

This table shows the three methods, their relative computation time (relative to no subpixel improvement) and their accuracy variance (in pixels).

Subpixel Method	Computation Time	Variance, in Pixels
none	1.00	1.2
peak center	1.02	0.5
search	1.40	0.2

For example, if you only care about the number of corners present, then you could use the "none" method as this is the fastest, or the "peak center" method to get better accuracy with a small increase in computation time.

NOTE: On images with many, closely spaced corners, the "search" ***subpixel method*** might report corner positions between actual corners. Try using the "peak center" method to correct this.

Sort results by selects the way the output array of "corner points" is sorted:

- Corner strength (the default)
- Corner X location
- Corner Y location

X or Y sorting is useful when you are looking at corners that are arranged in X or Y. The Bolt Thread Example, below, uses sorting by X location.

Outliers Parameters

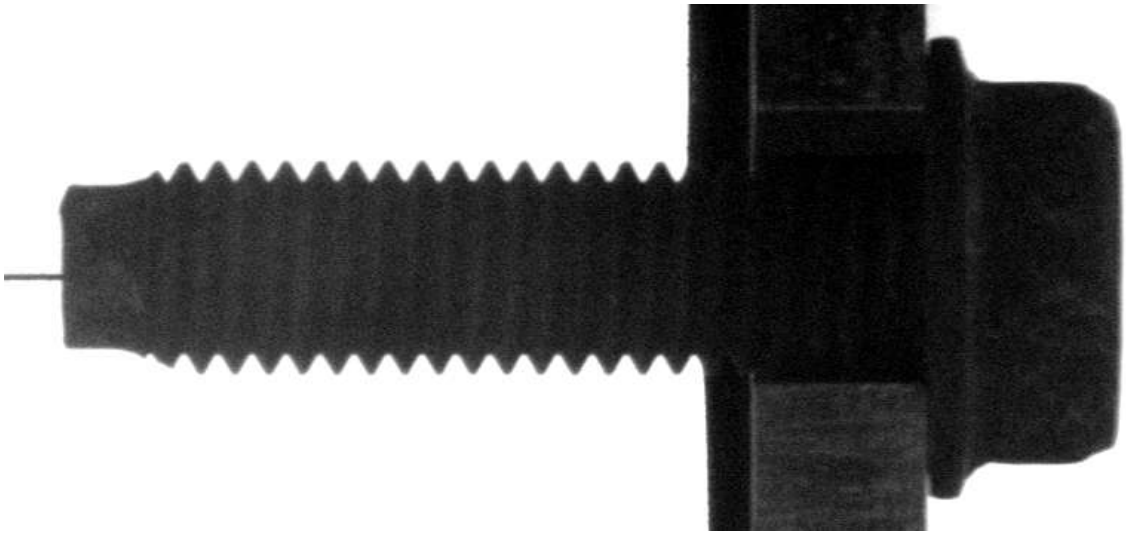
When looking at a periodic set of corners such as a bolt, IC pins, or the pins or "fingers" on an electrical connector, we can suppress corners away from this set of corners using the Outliers Parameters. If ***remove*** is true, then line is fit to the set of found corners and any corners further than the ***remove beyond*** distance (in pixels), the from this line (the "outliers") are removed. If remove is false, the fit is not computed and no outliers are removed.

Outputs

This algorithm outputs the ***number of corners*** found, an array of ***corner points***, sorted according to the ***sort results by*** parameter, an array of ***corner strengths*** where the strengths have been normalized to the 0 to 255 range. The algorithm also outputs a ***max response*** value, which is the maximum corner strength found, with no normalization. This value is useful for setting the ***empty threshold*** parameter – run the corner finder on an empty ROI (the part is not in the ROI but the conveyer belt is, for example), and use the ***max response*** value, decreased by some amount for noise, to set the ***empty threshold*** parameter.

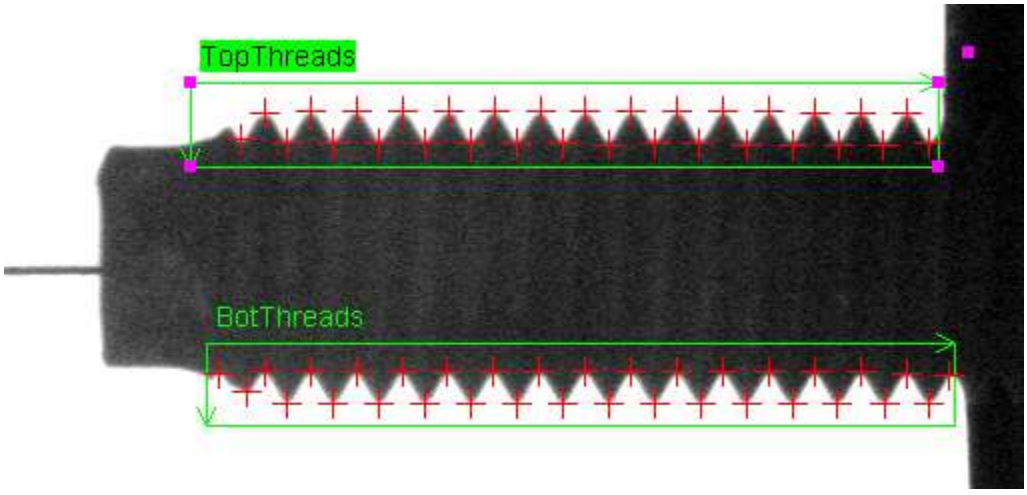
Bolt Thread Example

The customer is measuring spacing between the "peaks and valleys" of a machine bolt thread. We use back lighting to generate a high-contrast image of the bolt's threads:



This image is quite good, but you can get an even better image by using collimated light and a telecentric lens – for an additional cost.

We use two rectangle ROIs, called "TopThreads" and "BotThreads" and the "Corner Finder" algorithm:



The "search" method is used for best accuracy and the "corner points" output array are sorted by X location so we can measure peak-to-valley spacing on the threads. Formulas compute the peak-to-peak, valley-to-valley distances in X and the peak-to-valley distances in Y. These measures are then compared with tolerances to pass or fail the bolt.