

Sherlock 7 Technical Resource

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Search Geometric

Search utilities

A common task in machine vision applications is to train a feature in one image and search for it in other images. This may be done for several reasons:

- To verify that a part (resistor, bolt, label, pill) is present
- To determine how well an instance of the feature in an image matches a "golden template" instance of the feature
- To determine the location of a feature relative to other features

Sherlock 7 includes these search tools:

	Strengths	Limitations
Correlation	Accurate and fast	Allowing for image
Creates a map of the	Very good at coping with changes	scaling and rotation can
grayscale values within the	in illumination and focus	increase execution time
ROI	Can find multiple matches	significantly
Geometric	Finds matches at any rotation	Does not allow for image
Creates a model of edges in	Can find multiple matches	scaling
the feature		
Line Based	Optimized to look for straight edges	Can find only one match
Creates a model of straight	Finds matches at any rotation	
edges in the feature	Allows for scaling	
	Generally runs faster than	
	Geometric	
Verify Pattern	Can be trained on more than one	Can search for only one of
An expansion of Search	pattern	its trained patterns at a
Correlation that can be	Works in color images	time
trained on more than one		
pattern.		

Search Geometric works from Rectangle ROIs only.

Search Ge

Search Geometric works on monochrome images only.

Search Geometric creates a map of a set of edges, then looks for the same edges in new images.

To use Search Geometric

- 1. Train a good example of the feature
- 2. Define the search area
- 3. Acquire a new image, search for the feature and get its location, match score, and other information

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Train the feature

Surround the feature with a rectangular ROI and select the **Search Geometric** algorithm from the ROI's algorithm list. As soon as the algorithm is selected, the edges are automatically trained.

After the edges are trained, the algorithm is automatically put into run (search) mode.



Define the search area

Expand the same ROI to define the search area. A smaller search area results in less processing time, so restrict the search area to that part of an image where you know the pattern will occur.



Acquire a new image and search

In run mode, **Search Geometric** finds the best matches for the set of edges, and returns the location and score of the found matches. **Search Geometric** searches the full 360 degrees to find the best match to the trained edges.

RectA.Search - Geometric.num matches	1.000
RectA.Search - Geometric.best point	(243.815, 394.909)
RectA.Search - Geometric.best angle	78.080
RectA.Search - Geometric.best score	94.235



Here a less-than-perfect match was found; note the lower score.

RectA.Search - Geometric.num matches	1.000
RectA.Search - Geometric.best point	(334.175, 303.991)
RectA.Search - Geometric.best angle	3.961
RectA.Search - Geometric.best score	85.029



Run (search) parameters

The **Common** parameters are, as the name implies, the parameters you most often change to control how the algorithm finds a match.

	Common	
	execution mode	Run
	patterns to find	1
	min score	30
	early termination score	90
	reversed polarity	False

execution mode – You can train a new feature model by changing **execution mode** to **Train** and clicking the **Parameter** dialog's **Apply** button.

If you set **execution mode** to **Train**, be sure to set it back to **Run** before exiting the **Parameters** dialog. If you leave the algorithm in **Train** mode and run the investigation, every execution of the algorithm will result in a retraining!

patterns to find – By default, the algorithm finds one (the best) match for the feature. Change this parameter if you want to find more than one match.

min score – Only matches with scores equal to or greater than min score are returned.

early termination score – As soon as a pattern with this score or greater is found, the search terminates. This can result in decreased processing time, but it can also result in the skipping of patterns with scores greater than those returned as matches. (See **min sites to visit**.)

reversed polarity – Some surfaces – metal, for example – can give a "negative image" if there is a change in their angle relative to the light source. In this case, **Search Geometric** may find an incorrect or no match, because the edges, even though visible, do not have the same dark-to-light transitions as in the trained pattern. If this can happen in your investigation, set reversed polarity to **True** to make **Search Geometric** look for matches in normal and reversed polarity.



reversed polarity = False; bad match



reversed polarity = True; good match

The **Advanced** parameters provide more control over how the algorithm trains on edges and finds a match. Some of these parameters are applied at train time, others at run time.

Changing these parameters requires in-depth knowledge of the image and its edges.

Advanced	
manual optimization	False
pattern level	0
scene level	0
ignore small curvatures	False
min contour length	20
max contour length	10000
proximity exclusion radius	24
edge level	17
min sites to visit	25
show used edges	True
min angle (degrees)	-180.00
max angle (degrees)	180.00

manual optimization – If **True**, the values you set for the next three parameters (**pattern level**, **scene level**, **ignore small curves**) are applied; if **False**, they are calculated by the algorithm based on image content.

pattern level – Specifies how much information from the trained pattern is used during the search for matches. The higher the number, the more edge points are skipped in the trained pattern. Very high numbers can result in decreased processing time, but they can also result in false matches or missed good matches.

Value	Meaning
0	Skip no points use all the information
1	Skip every other edge point
2	Skip two edge points, use the 3^{rd} , skip two edge points, use the 6^{th} , etc.
50 (maximum value)	Skip 50 edge points, use the 51^{st} , skip 50 edge points, use the 102^{nd} , etc.

scene level -- Specifies how much information from edges found in the ROI is used during the search for matches. The higher the number, the more edge points are skipped in the found edges.

ignore small curvatures – If True, small curvatures and small straight lines are ignored.

min contour length – At train time, edges that are composed of fewer than this many points are not included in the feature.

At train time, with **min contour length** set low (10), most edges inside the ROI are included in the trained pattern.



At run time, when applied to a similar pattern without small edges, the algorithm finds the pattern, but with a low score.

N.	RectB.Search - Geometric.best score	58.983
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At train time, with **min contour length** set higher (30), smaller edges inside the ROI are not included in the trained pattern.

At run time, when applied to a similar pattern without small edges, the algorithm finds the pattern with a high score.

N RectB.Search - Geometric.best score 94.93

At run time, when applied to a similar pattern with small edges (less than 30), the algorithm finds the pattern with a high score. The small edges in the ROI are ignored.

N RectB.Search - Geometric.best score 97.844









At train time, **min contour length** set to 30. (Because there are no small edges, **min contour length** could be set much higher.)

At run time, when applied to a similar pattern with small edges, the algorithm finds the pattern with a high score. The small edges in the image are ignored.

N RectB.Search - Geometric.best score 97.033





max contour length - A series of connected points that contains more than this many points is not used in the match. This is applied when the edges are trained. At train time, edges greater than this length are not included in the feature.

For **min contour length** and **max contour length**, only edges that were included in the edge map at train time are taken into consideration when determining how well a feature in a new image matches the map. Edges that are in the new image but not in the edge map do not affect the match score. However, edges that are in the edge map that are not found in a new image do affect (lower) the match score.

proximity exclusion radius – The minimum distance between two reference points for overlapping objects. If two or more matches are found within this distance of each other, only the best match is returned.

edge level – Points with gradient amplitude equal to or greater than this are candidates to be edge points. Gradient amplitude is calculated from four contiguous pixels:

 $edge \ level = [P3 + P4] - [P1 + P2]$

min sites to visit – If **early termination score** is set to 100, the search stops after this many potential matches have been analyzed.

show used edges – If **True**, the edges from the trained pattern are displayed; if **False**, they are not. This is a matter of viewer preference only; it does not affect algorithm execution. If **show used edges** is set to **True** and the algorithm finds no matches, the edges are drawn at the upper-left corner of the ROI; this sometimes confuses users into thinking that that is where the best match was found.

Search Geometric Page 7 v 1.2 August 9, 2012 **min angle (degrees)** – The greatest counterclockwise angle of rotation at which the search will find the feature. Expressed as a negative angle from 0 to -180.

max angle (degrees) – The greatest clockwise angle of rotation at which the search will find the feature. Expressed as a positive angle from 0 to 180.

Editing the edges

After you train a set of edges, you can edit them by clicking the algorithm's **Parameters** button. Edges appear as green dots (admittedly somewhat difficult to see, especially on the printed page).

Delete points – Delete individual points by clicking on them, or by holding down the left mouse button and dragging the mouse pointer across points.

Delete – Delete an edge (a set of connected points) by clicking on any point in the edge.

Undelete – Return a deleted point or set of connected points to the edge. If you previously deleted discrete points on an edge, clicking anywhere on the edge returns all deleted points to the edge.

In this image, a piece of dust has strong edges that you do not want to match in acquired images. Click the **Delete** button and click on any point in its edge to delete all the points.

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Model edit mode
🖌 Delete points 🖸 Undelete 🔇 Delete

After you delete edge points, do not retrain the feature. If you set **execution mode** to **Train** and click the **Apply** button, all edges are retrained, and your deletions will be lost.

Reference point

When you train a set of edges, **Search Geometric** calculates the offset of the centroid of the edges from the upper-left corner of the ROI, and defines this as the pattern's initial **reference point.**

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Train mode

The upper-left corner of the ROI is at (227,205). The centroid of the edges is at (320, 240). This is the value returned as the **best point** reading. The **reference point** is at (93,35) [(320-227, 240-205)]



Ξ	Reference Point	
	x	93.000
	У	35.000

Changing the reference point changes the returned **best point** reading by the same amount. For example, if instead of the centroid of the edges, you want the algorithm to return the upper-left corner of where the ROI was in relation to the centroid of the edges when trained, set both \mathbf{x} and \mathbf{y} to 0.

Run mode, reference point set to (0,0)

Note that the **best point** is offset (0,0) from the upper-left corner of where the ROI was in relation to the centroid of the edges when trained (red rectangle), not where the ROI is now at run time (green rectangle).

The upper-left corner of where the ROI was at train time is at (227,205). The **best point** is at (227,205).



You can set \mathbf{x} and \mathbf{y} to any positive values, even ones that would cause **best point** to be outside the extent of where the train-mode ROI would be. You cannot set \mathbf{x} and \mathbf{y} to negative values.

Returned values (readings)

num matches – The number of matches, up to a maximum of **patterns to find.**

best point – The location of the best match

best angle – The angle of the best match. The angle is returned in degrees or radians, depending on the setting in Sherlock's

Options → **Application** dialog.

best scale – The scale of the best match, as a percentage of the trained feature.

best score – The score of the best match. A perfect match will return a score of 100.

pattern left and **pattern right** – Two points created by the algorithm, centered about **location** and separated by the width of the ROI when the feature is trained. **Pattern left** and **pattern right** can be used as landmarks in an alignment scheme that needs to calculate rotation.

If **patterns to find** is greater than 1 and more than one match is found

all points[] – the locations of the matches, ordered according to **all scores**[].

all angles[] – the angles of the matches, ordered according to **all scores**[].

all scales[] – the scales of the matches, ordered according to **all scores**[].

all scores [] – the scores of the matches, ranked from highest to lowest.

The first element of each array contains the same information as its corresponding scalar reading. (E.g., **all points[0] = best point**.)



RectB.Search - Geometric.pattern left	(283.997, 240.018)
RectB.Search - Geometric.best point	(319.997, 240.008)
RectB.Search - Geometric.pattern right	(355.997, 239.997)

RectB
Alg RectB.Search - Geometric
N num matches
P best point
N best angle
N best scale
N best score
P pattern left
P pattern right
P[] all points
N[] all angles

N[] all scales

NI all scores

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