Computer Vision

Labelling and Blob measurement

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Labelling and Blob measurement

Overview:

- **Blob connectivity (4 or 8)**
- **Label blobs**
- **Blob analysis**
- **Blob measure (*)**
- **Remove blobs**
- **Remove labels**
- **Blob And (*)**
- **Find and fill holes**
- **Remove border objects**

Blob Connectivity

Blob = Binary Linked Object.

- **Eight-connected:**

- **Four-connected:**

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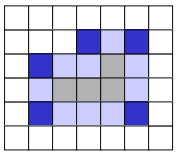
Blob versus background duality



= object
= smallest background if four-connected object
+ = smallest background if eight-connected object

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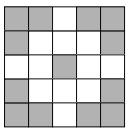
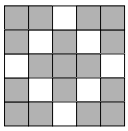
Blob versus background duality

- **A blob and its four closest neighbour blobs**
  - **blobs are eight-connected and the background is four-connected**



  - **blobs are four-connected and the background is eight-connected**



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Label Blobs

int LabelBlobs (orgImage, labelImage, connected)

The label blobs operator takes a binary image and produces a labelled image. The parameter connected has the value eight-connected or four-connected and determines how the blobs are connected.

The background pixels will get the value 0.

All pixels belonging to a blob will get the same value. Pixels belonging to different blobs will get different values.

The return value is the total number of found blobs.
(= highest label number)

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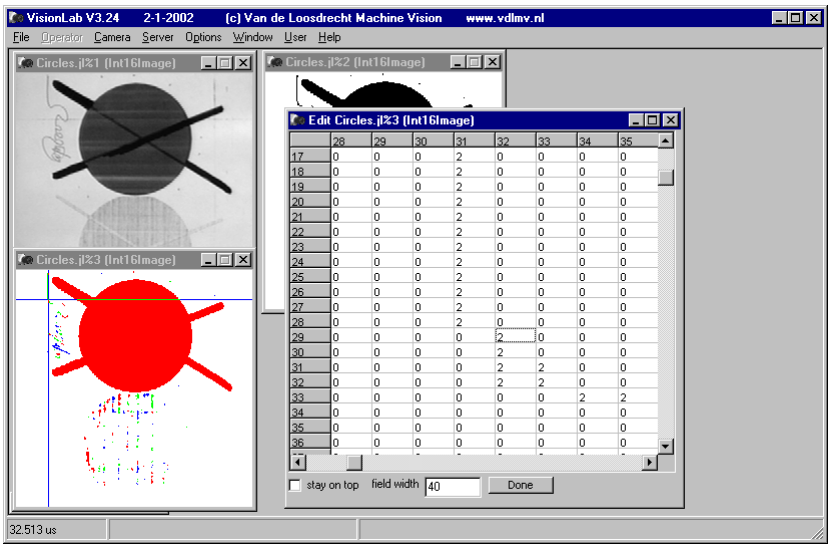
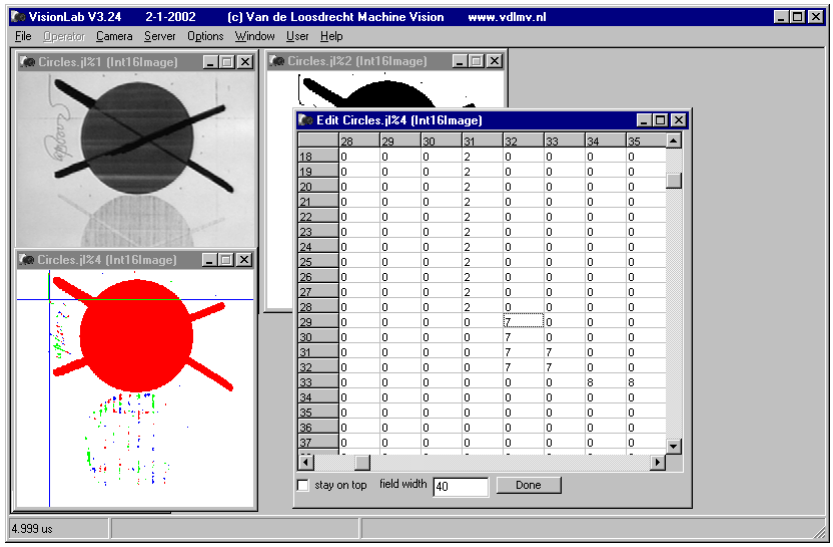
Demonstration LabelBlobs

- **Demonstrate difference between eight and four connected**
  - **Open image circles.jl**
  - **Threshold 0 130**
  - **LabelBlobs EightConnected, note result is number of blobs**
  - **LabelBlobs FourConnected, note result is number of blobs**
  - **Show with analyse|edit difference at co-ordinate (32,29)**

LabelBlobs EightConnected



LabelBlobs FourConnected



Label blobs iterative algorithm (*)

- **Binary image:**

	1	1		1	1	
	1	1		1	1	
	1	1	1	1	1	

- **Give each object pixel a unique positive value**

	1	2		3	4	
	5	6		7	8	
	9	10	11	12	13	

Label blobs iterative algorithm (*)

- **Repeat until no changes**
  - **Down pass (top left to right bottom): give each pixel the minimum value of its 8 neighbours**

	1	1		3	3	
	1	1		3	3	
	1	1	1	1	1	

  - **Up pass (right bottom to top left): give each pixel the minimum value of its 8 neighbours**

	1	1		1	1	
	1	1		1	1	
	1	1	1	1	1	

Note: VisionLab uses a more complex, but faster 2 pass algorithm

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Blob Analysis

BlobAnalysis (image, set, nrLabels, blobs, modifier)

- **Analyse an image with labelled blobs**
- **set defines the analyse tools to be used**
- **nrLabels is the highest value of the label in the image, this value is returned by operator LabelBlobs**
- **blobs contains a description of the analysed blobs**
- **modifier is an optional parameter which can override the default behaviour of certain analyse tools (*)**

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Blob Analysis

- **Analyse tools**
  - **Area**
  - **Surrounding box**
  - **Bounding box**
  - **Extreme points**
  - **Centre of gravity**
  - **Perimeter**
  - **Eccentricity, [0 (circular) .. 1 (line)], based on moments**
  - **EllipsFit, Area / (PI *0.5*Length*0.5*Breadth)**
  - **Form factor , [0 (line) .. 1 (circular)], $4*pi*area/perimeter^2$**
  - **Nr of holes**
  - **Area of holes**
  - **AreaHolesRatio = Area of holes / Area**
  - **Orientation**
  - **ExCircle, approximation for the smallest circle that enclosed the blob. Based on the middle of longest distance between pixels on the border**
  - **InCircle, the biggest circle that is enclosed in the blob**
  - **MaxCord, maximum distance between 2 pixels in blob**

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Blob Analysis (*)

- **Analyse tools (continued)**
  - **PolygonVertices: calculates the number of vertices for the approximate polygon of the blob**
  - **Sum of co-ordinates: x, xx, y, yy and xy**
  - **Net moments in xx, yy and xy**
  - **Hu moments Hu1 .. Hu7 (translation, rotation and size invariant)**

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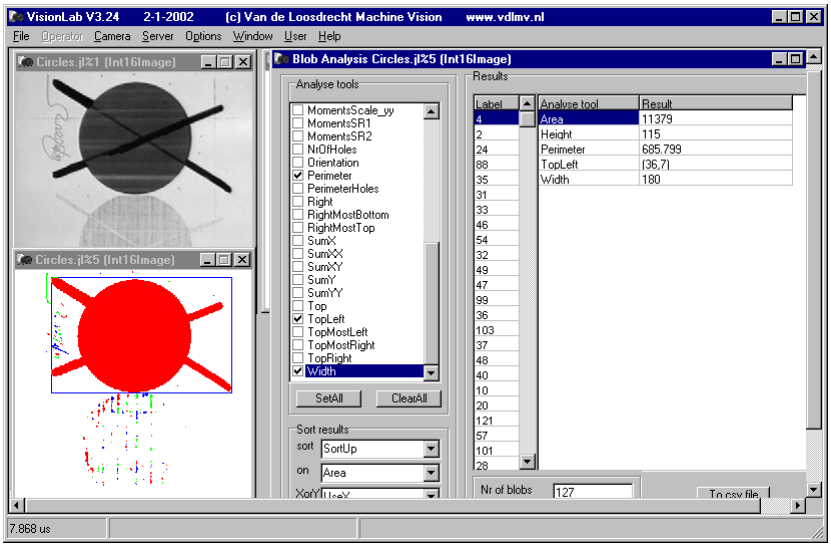
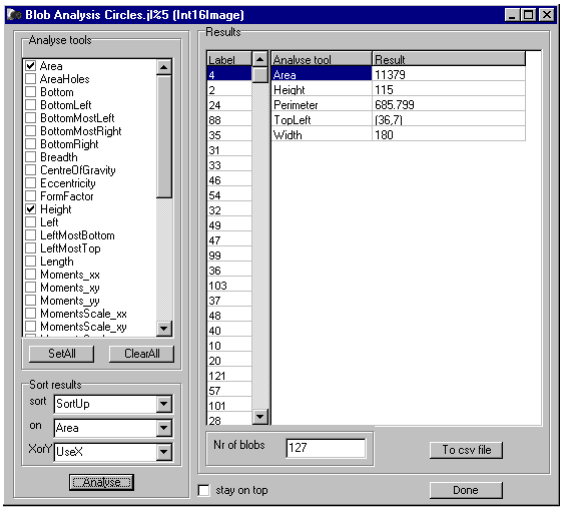
Demonstration Blob Analysis

- **Open image circles.jl**
- **Threshold 0 130**
- **LabelBlobs EightConnected**
- **BlobAnalysis Area Height Perimeter TopLeft Width, demonstrate clicking at label to show measurements**

BlobAnalysis Area Height Perimeter TopLeft Width

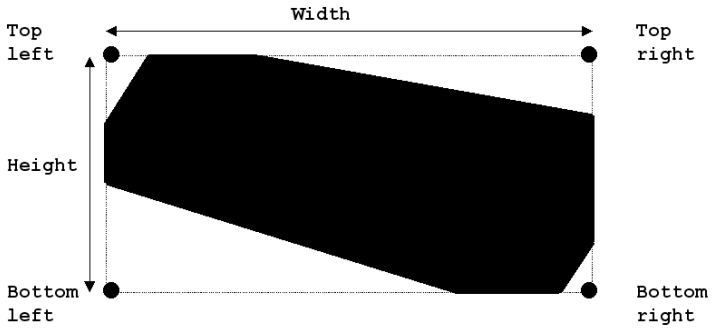


BlobAnalysis Form

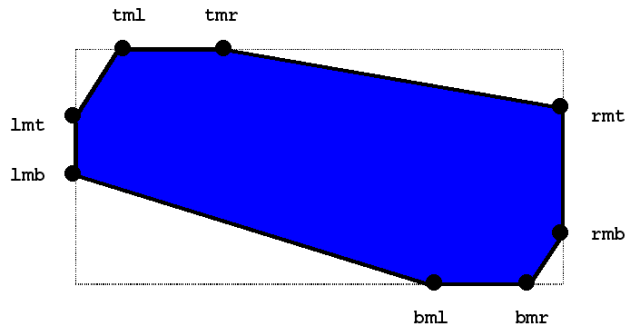


Surrounding box

Description of the smallest rectangular box around the blob and aligned to x and y axis.



Extreme points in surrounding box



tml: top most left
tmr: top most right
rmt: right most top
rmb: right most bottom
bmr: bottom most right
bml: bottom most left
lmb: left most bottom
lmt: left most top

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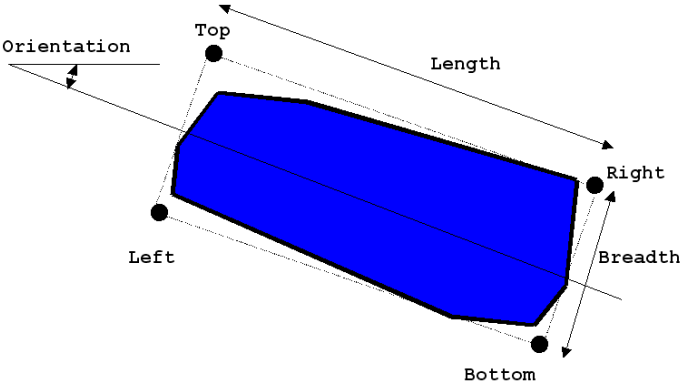
Bounding box

Description of the smallest rectangular box around the blob and aligned to the orientation of the principle axis.



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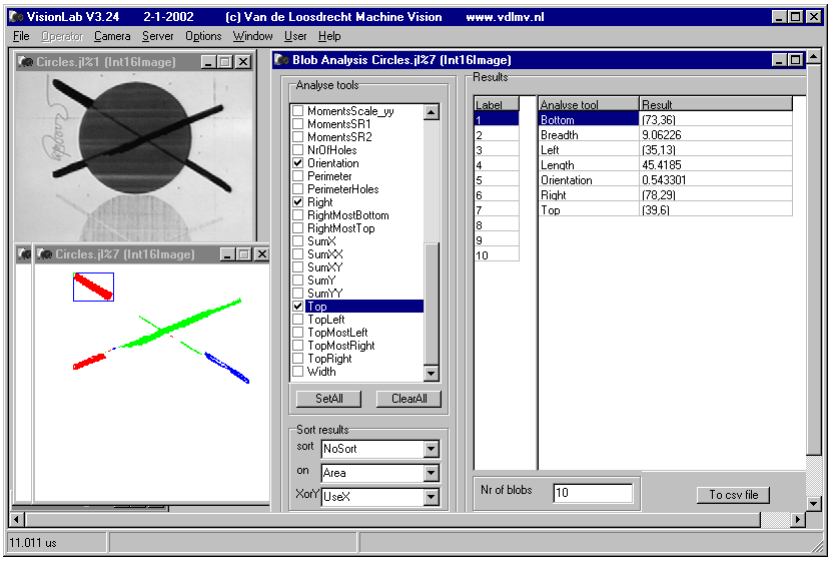
Demonstration Bounding Box

- **Open image circles.jl**
- **Threshold 0 40**
- **LabelBlobs EightConnected**
- **BlobAnalysis Bottom Breadth Left Length Orientation Right Top**

BlobAnalysis Bottom Breadth Left Length Orientation Right Top



scale, size and position invariant features (*)

- **Hu1**
- **Hu2**
- **Hu3**
- **Hu4**
- **Hu5**
- **Hu6**
- **Hu7**
- **Eccentricity**
- **EllipsFit**
- **FormFacor**
- **NrOfHoles**
- **LengthBreadthRatio**

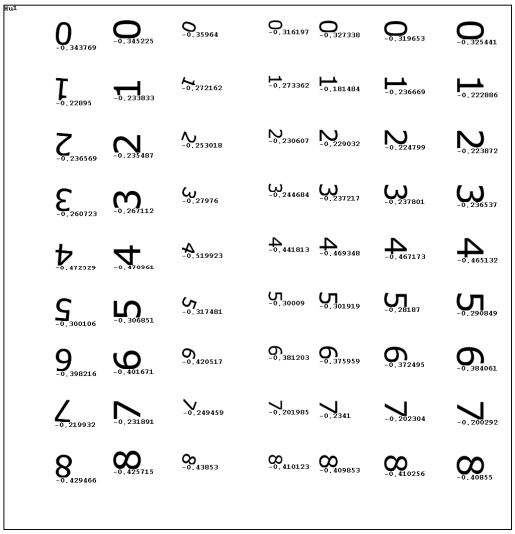
Demonstration scale, size and position invariant features (*)

- **Open script demo_invariants.jls**
- **Run script**
- **Analyze results in order to see the invariance**

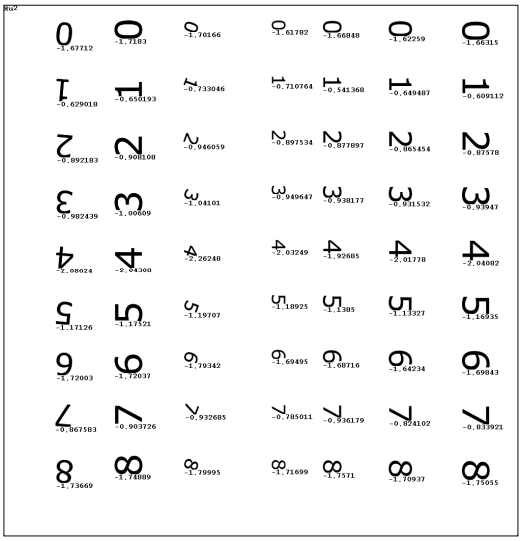
Notes:

- **Because of the high dynamical range of Hu moments a logarithmical scaling function is used. For symmetrical objects the Hu moments can produce very small numbers around 0, because of logarithmical scaling this will result in values with a 'big' sign change. See the "zeros" for Hu5, Hu6 and Hu7.**
- **No "nines" are used in this example because they are rotations of "sixes".**

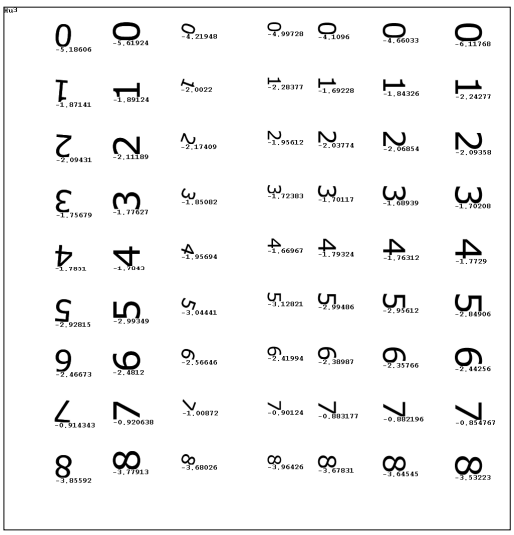
Hu1 (*)



Hu2 (*)



Hu3 (*)



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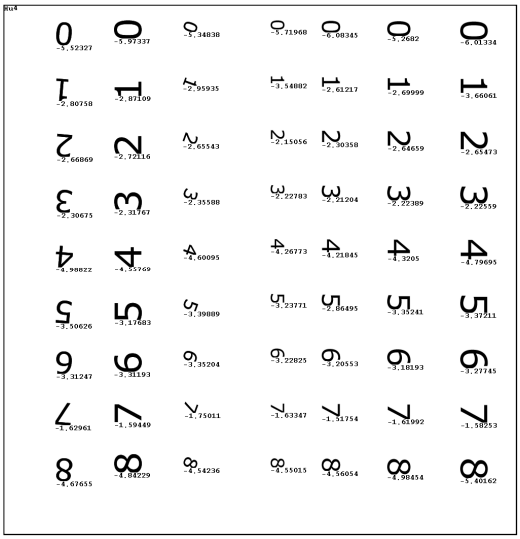
Hu4 (*)



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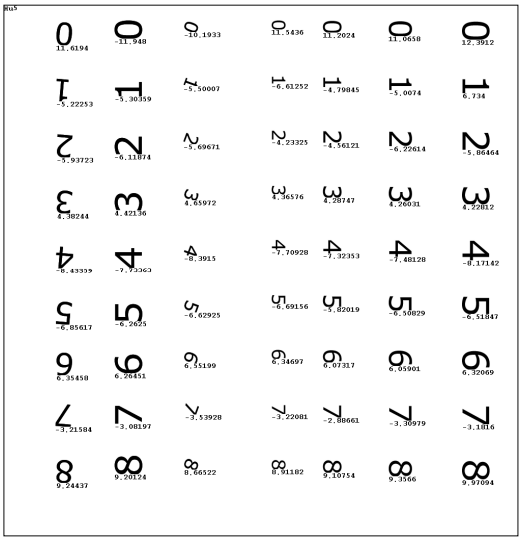
Hu5 (*)



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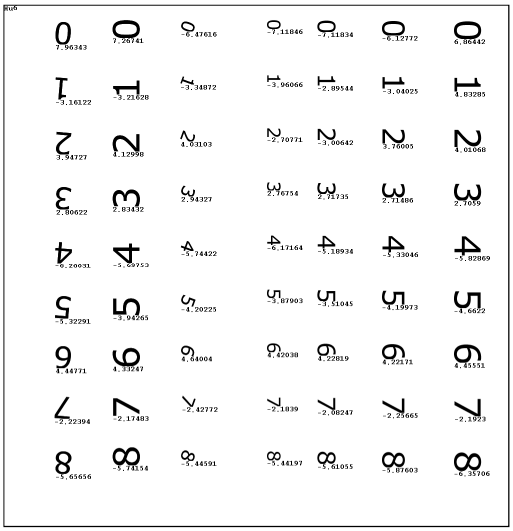
Hu6 (*)



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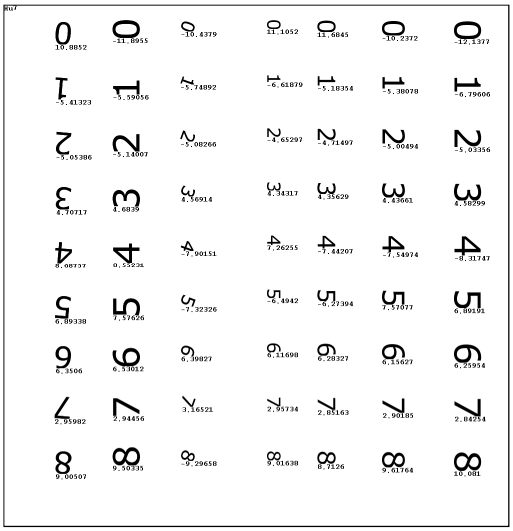
Hu7 (*)



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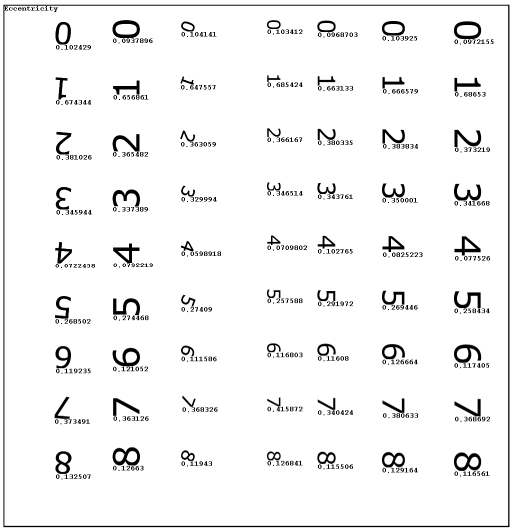
Eccentricity (*)



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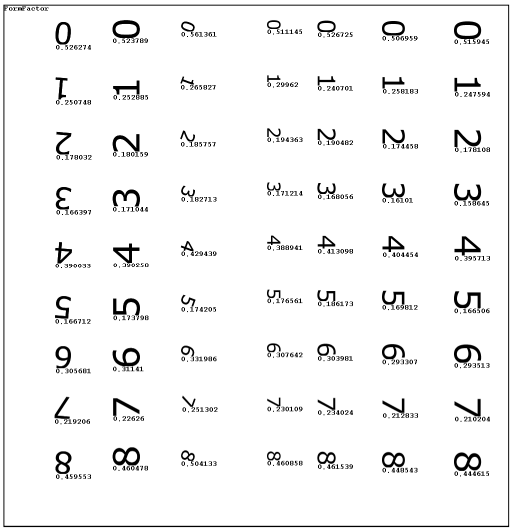
FormFactor (*)



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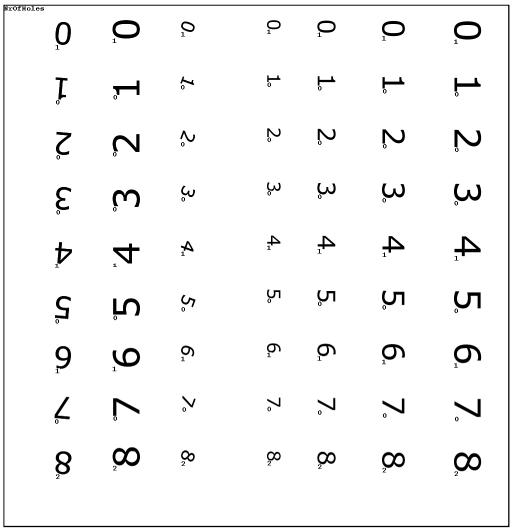
NrOfHoles (*)



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Demonstration Hu7 to determine if object is mirrored (*)

- **Open image four5s.jl**
- **ThresholdIsoData DarkObject**
- **Labelblobs**
- **BlobAnalyse Hus**

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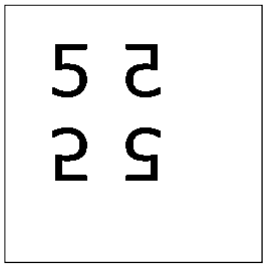
Demonstration sign of Hu7 (*)
to determine if object is mirrored



Hu7

6.89191 - 6.89191

-6.89191 6.89191

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Grayscale Blob Analysis

- **Analyse an image with labelled blobs**
- **Use “second image” grayscale image for extra grayscale measurements for each blob:**
  - **AveragePixel, the average of the pixel values**
  - **BendingEnergy, the energy in the sharp bendings in the perimeter**
  - **Curvature, the number of sharp bendings in the perimeter**
  - **IsoData, the "2 means value" of bi-modal distribution of the histogram**
  - **MaxPixel, the maximum of the pixel values**
  - **MedianPixel, the median of the pixel values**
  - **MinPixel, the miniumum of the pixel values**
  - **ModalPixel, the modal of the pixel values**

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Grayscale Blob Analysis

- **StandardDeviation, the standard deviation of the pixel values**
- **SumPixels, the sum of all pixel values of the blob**
- **SumWX, the sum of the product of all pixel values and their x-coordinate**
- **SumWY, the sum of the product of all pixel values and their y-coordinate**
- **WeightedCoG, the weighted (by pixel value) centre of gravity of the blob**

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Demonstration Grayscale Blob Analysis

- **Open image circles.jl**
- **Threshold 0 130**
- **LabelBlobs EightConnected**
- **Select orginal grayscale image as "2nd selected"**
- **GrayscaleBlobAnalysis Area AveragePixel, BendingEnergy, Curvarture, MaxPixel, MedianPixel, MinPixel, ModalPixel, StandardDeviation**

  demonstrate clicking at label to show measurements

(Grayscale) Blob Analyse parameter modifier (*)

modifier is an optional parameter which can override the default behaviour of certain analyse tools

modifier is an optional parameter which can override the default behaviour of certain analyse tools.
This parameter is an array variable. Each array element can override the bevaviour for one tool.
Syntax is: <parameters> <value>. This parameter should be a reference to an array variable.

Possible parameters:
- bendingEnergyMaxEdgeDiff
- approxPolygonMinDistance

(Grayscale) Blob Analyse parameter modifier (*)

Parameter bendingEnergyMaxEdgeDiff:

This parameter influence the BendingEnergy and Curvature analyse tools. A Sharr edge detection is used to calculate the direction at the perimeter. If the difference in edge direction is bigger then maxEdgeDiff the position is a sharp bending. The scale factor used in the calculation = 1000.

The default value for bendingEnergyMaxEdgeDiff is 500.

Parameter approxPolygonMinDistance:

This parameter determines the behaviour of the analyse tool PolygonVertices. The polygon approximation search will stop if all pixels on the contour are closer then approxPolygonMinDistance pixels to the polygon. Minimum is 1 and default value is 10.

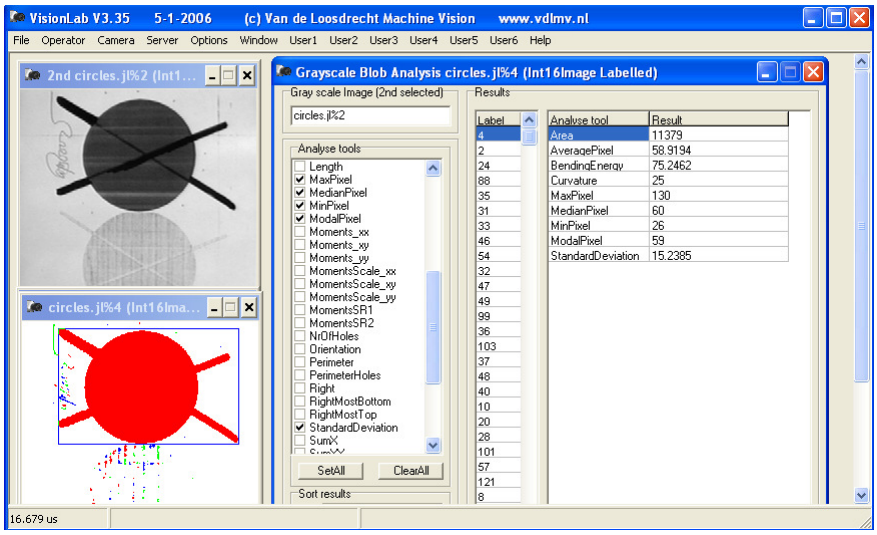
Example:

$baMod[0] = "approxPolygonMinDistance 5"

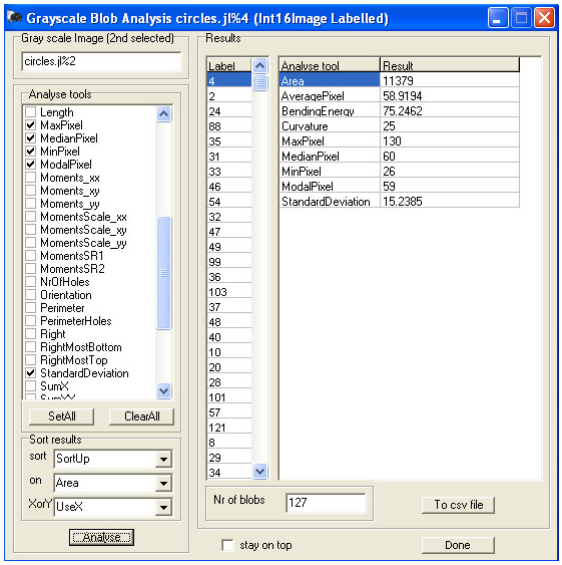
$baMod[1] = "bendingEnergyMaxEdgeDiff 300"

BlobAnalysisArray label &$tab SortUp Area UseX Area PolygonVertices &$baMod

Grayscale Blob Analysis



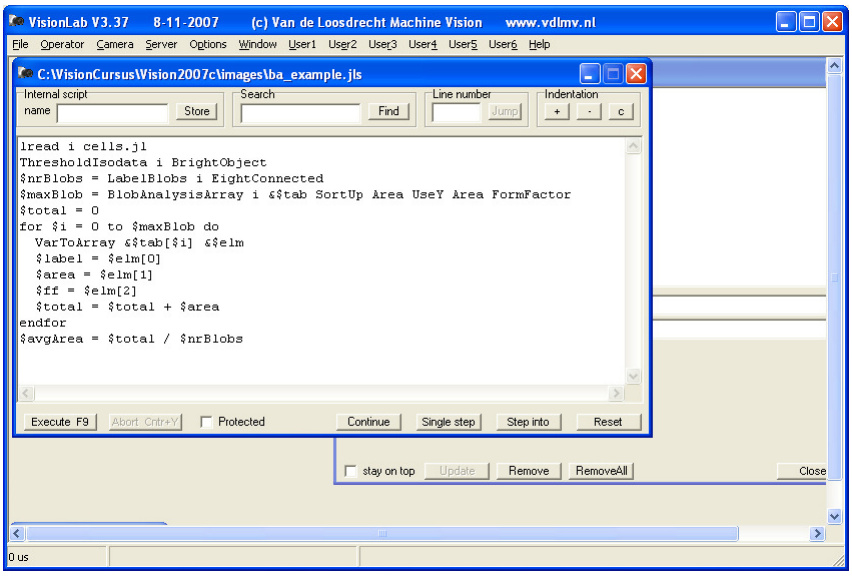
Grayscale Blob Analysis



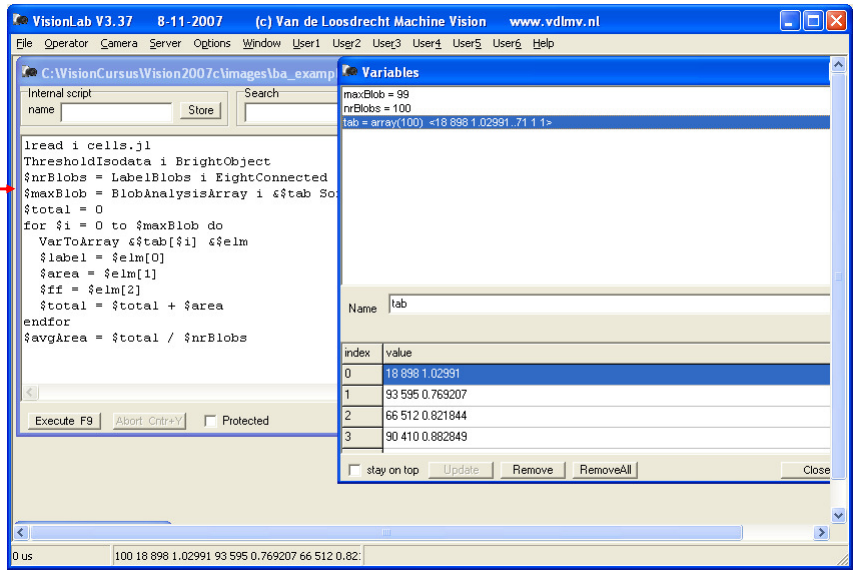
Demonstration using Blob Analysis from a script

- **Open scripts ba_example.jls**
- **Open variable screen (Server menu | Examine variables)**
- **Single step through script**
- **Notes:**
  - **result is returned to an array with name tab**
  - **Click on array name in top window of variable screen to examine details of array**
  - **each element of the array contains a line with: <labelnr> followed with the specified measurements**
  - **Each line is extracted from the array tab to an array elm**
  - **The element with index 0 of array elm is the labelnr**
  - **The element with index 1 of array elm is the area**
  - **The element with index 2 of array elm is the formfactor**
- **2nd part example alternative using string operations (*)**

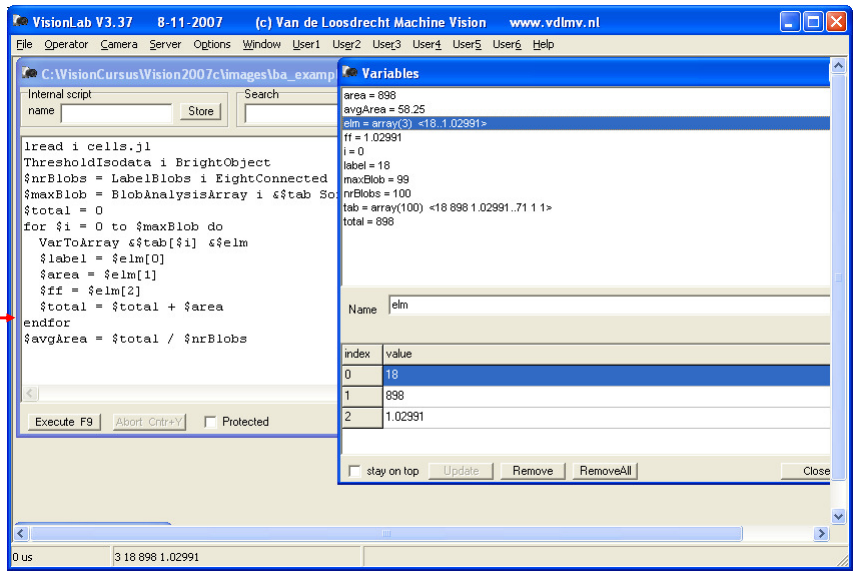
Single step through script



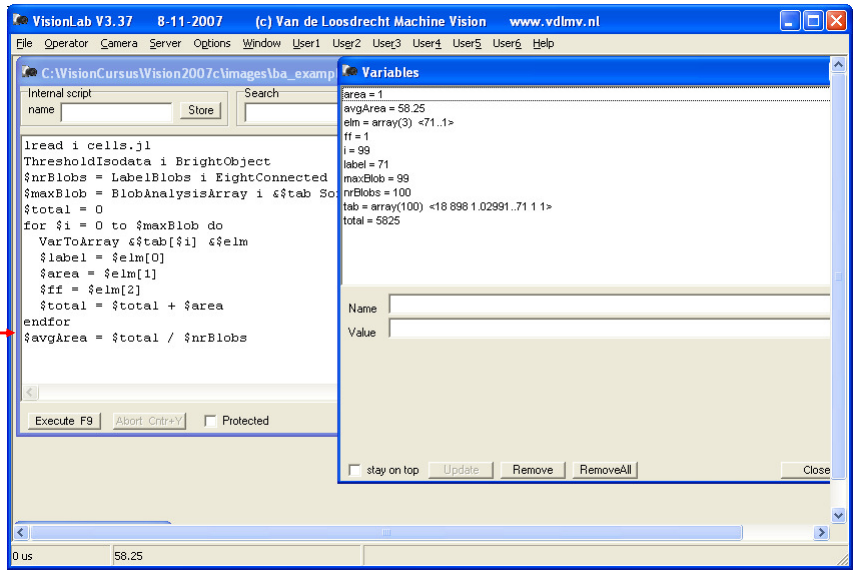
Single step through script



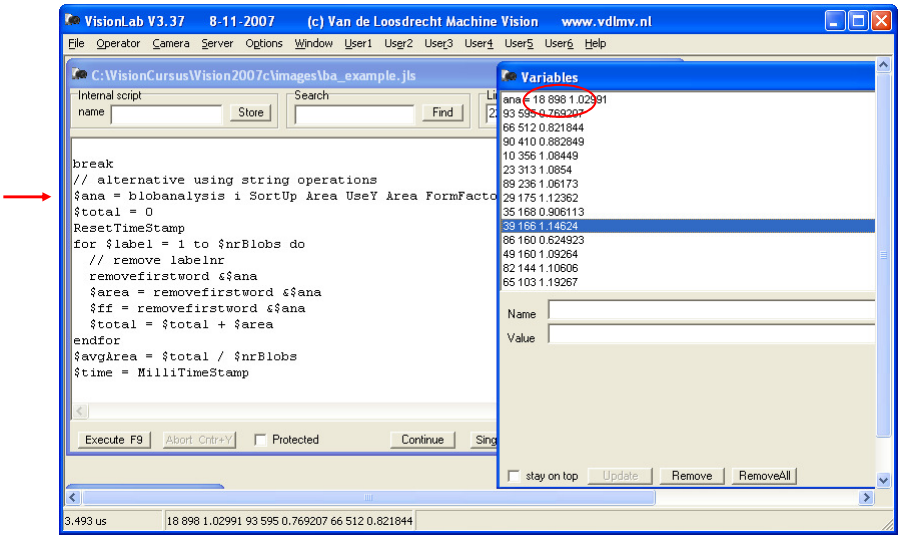
Single step through script



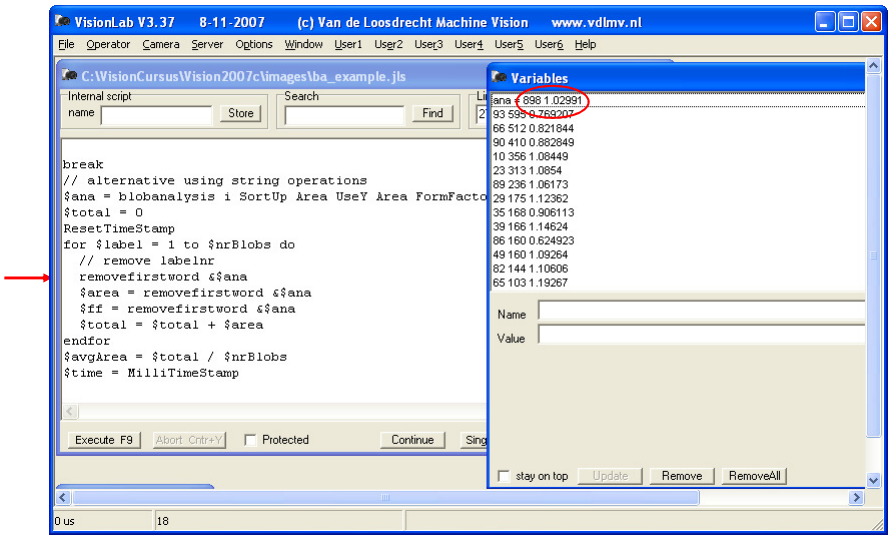
Single step through script



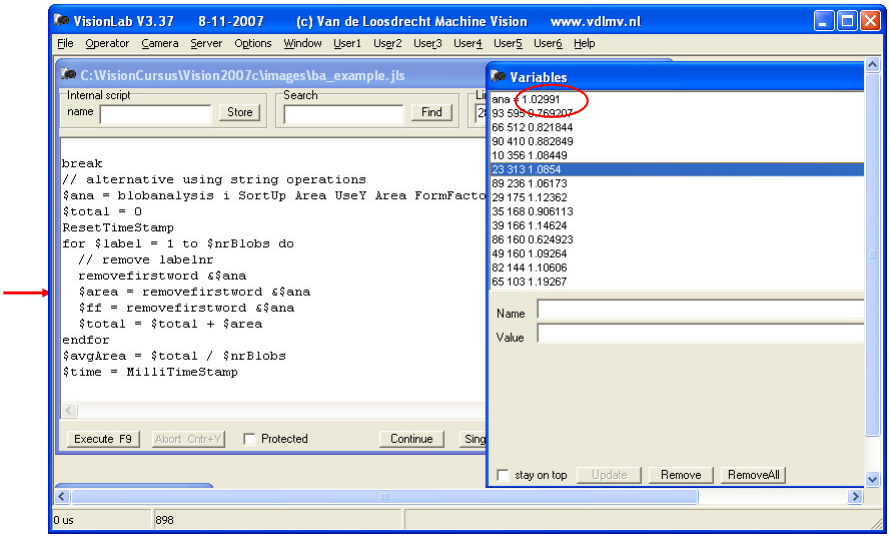
Alternative using string operations (*)



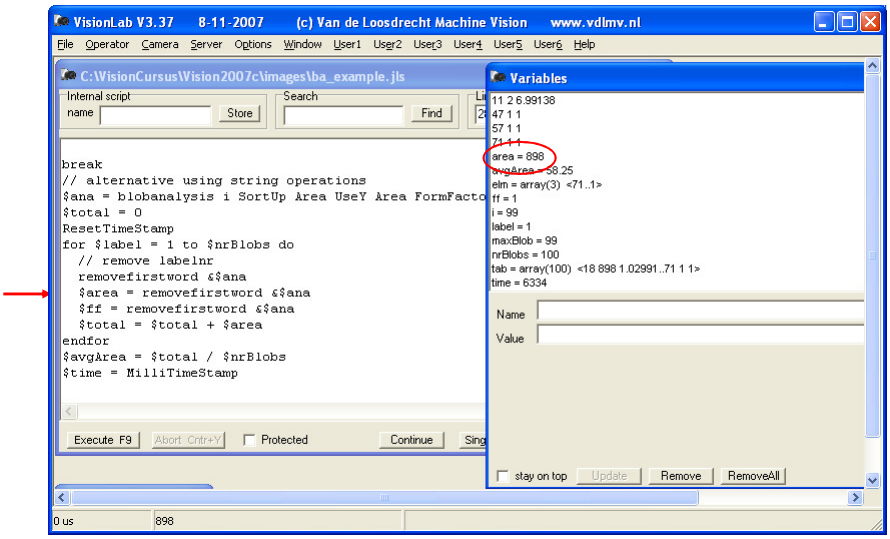
Alternative using string operations (*)



Alternative using string operations (*)



Alternative using string operations (*)



Blob Measure (*)

BlobMeasure (image, blobanalyse , scale, xory, [modifier])

**This operator measures blobs in a labelled image.
All pixels of a blob will get the same value according to the blobanalyse tool chosen.**

The parameter scale is used if the measurement delivers a floating point answer which must be represented in integer notation. In this case the answer is multiplied by scale.

The parameter xory is used if blobanalyse specifies a tool which measures a co-ordinate. This parameter specifies whether the x or the y of the co-ordinate is used for the result of the operation.

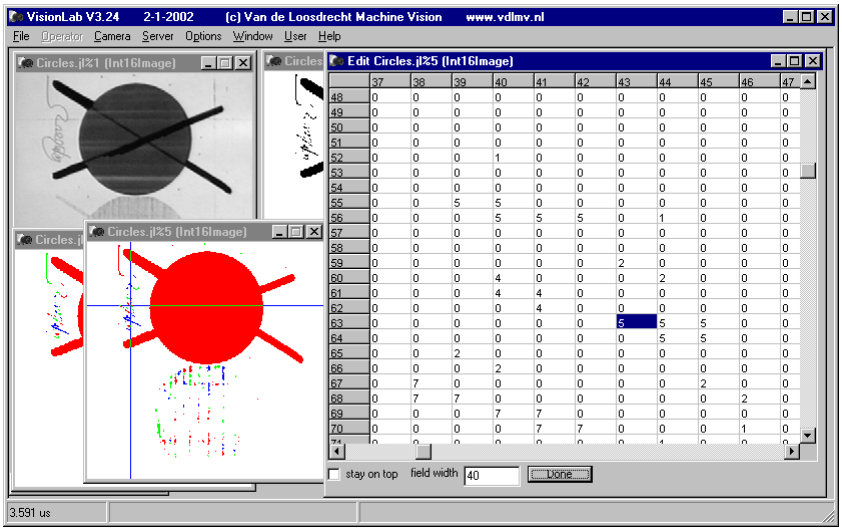
Grayscale Blob Measure (*)

- **Use "second image" grayscale image for extra grayscale measurements for each blob.**

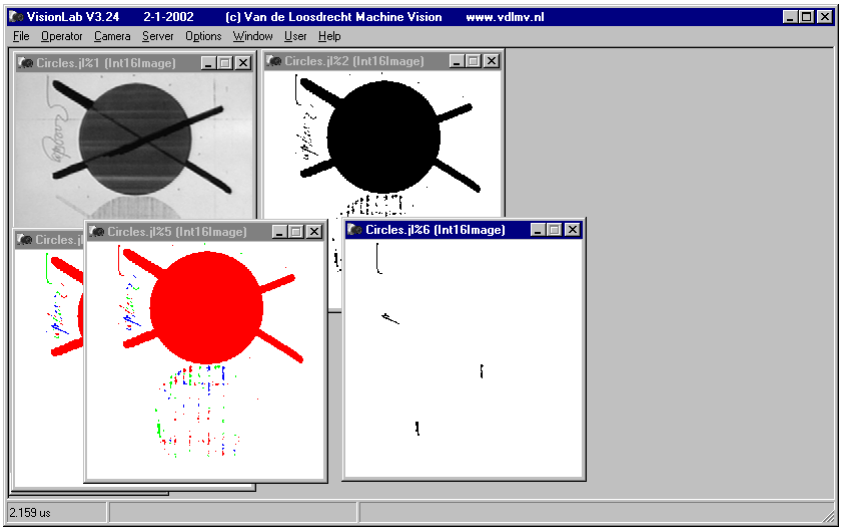
Demonstration Blob Measure (*)

- **Open image circles.jl**
- **Threshold 0 130**
- **LabelBlobs EightConnected**
- **BlobMeasure Area 100 UseX**
- **Threshold 20 10000, to find all blobs with an area between 20 and 10000 pixels**

BlobMeasure Area (*)



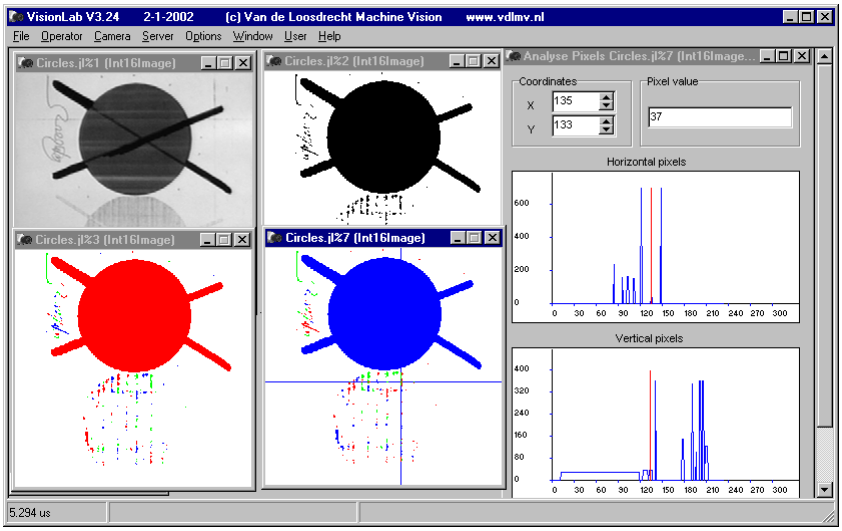
Threshold 20 10000 (*)



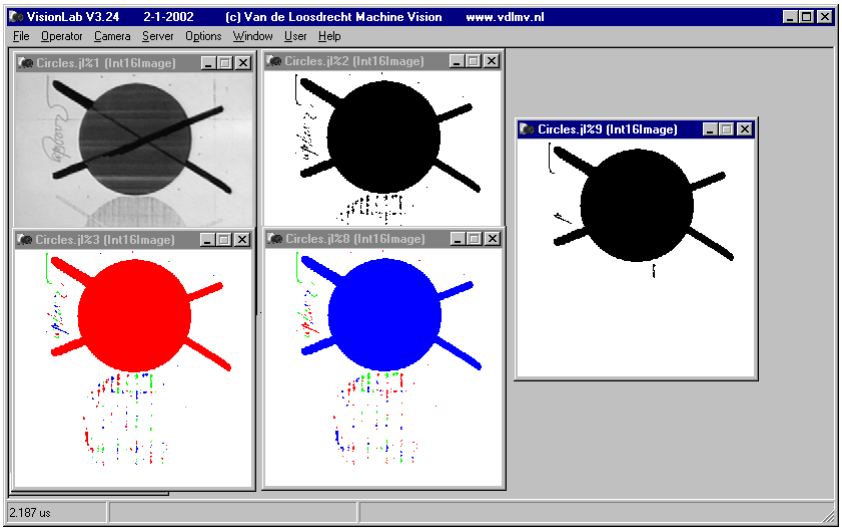
Demonstration Blob Measure (*)

- **Open image circles.jl**
- **Threshold 0 130**
- **LabelBlobs EightConnected**
- **BlobMeasure FormFactor 100 UseX**
- **Threshold 1 40, to find all blobs with 0.01 <= form factor <= 0.40**

BlobMeasure FormFactor 100 (*)



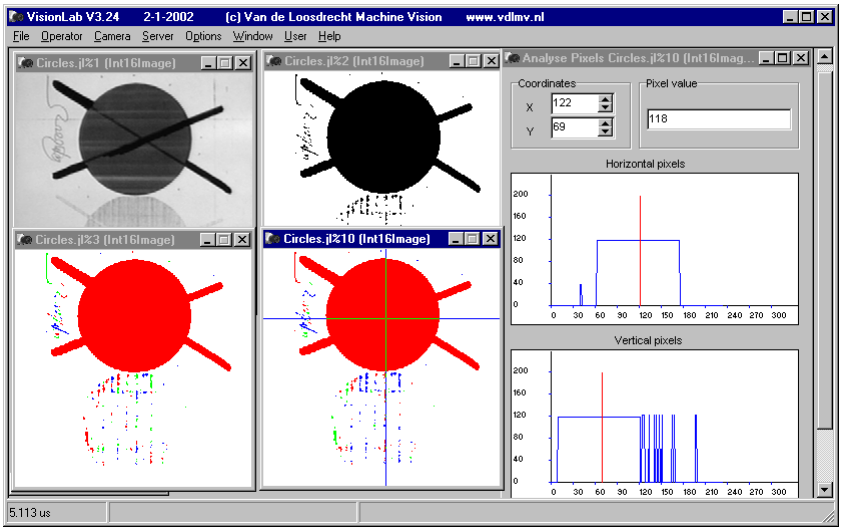
Threshold 1 40, to find all blobs
with 00.1 <= form factor <= 0.40 (*)



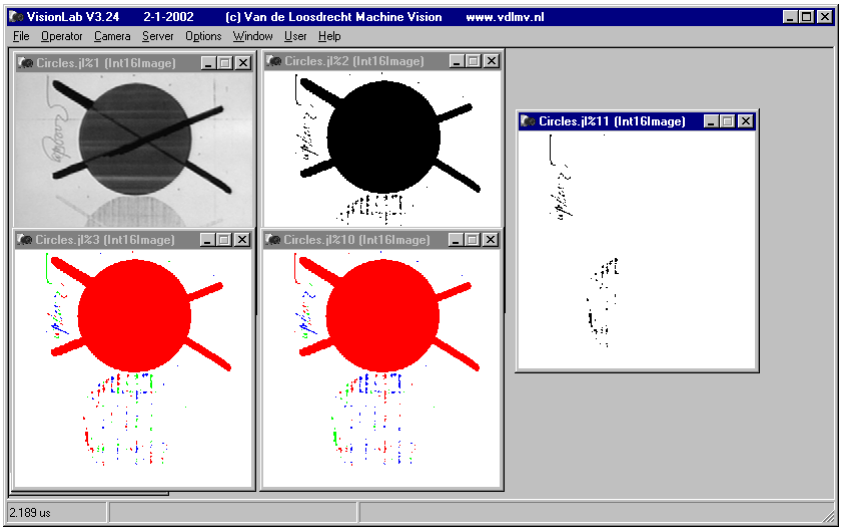
Demonstration Blob Measure (*)

- **Open image circles.jl**
- **Threshold 0 130**
- **LabelBlobs EightConnected**
- **BlobMeasure CentreOfGravity 100 UseX**
- **Threshold 1 100, to find all blobs with x co-ordinate of centre of gravity between 1..100**

BlobMeasure CentreOfGravity UseX (*)



Threshold 1 100, to find all blobs with x co-ordinate of centre of gravity between 1..100 (*)



Remove Blobs

RemoveBlobs (image, connected, blobanalyse, low, high, xory, [modifier])

This operator removes blobs in a binary image with name imageName. All blobs are measured according to the blobanalyse tool chosen and the blobs with measurement result in the range [low..high] are removed from imageName.

The parameter xory is used if blobanalyse specifies a tool which measures a co-ordinate. This parameter specifies whether the x or the y of the co-ordinate is used for the result of the operation.

The parameter connected has the value eightconnected or fourconnected and determines how the blobs are connected.

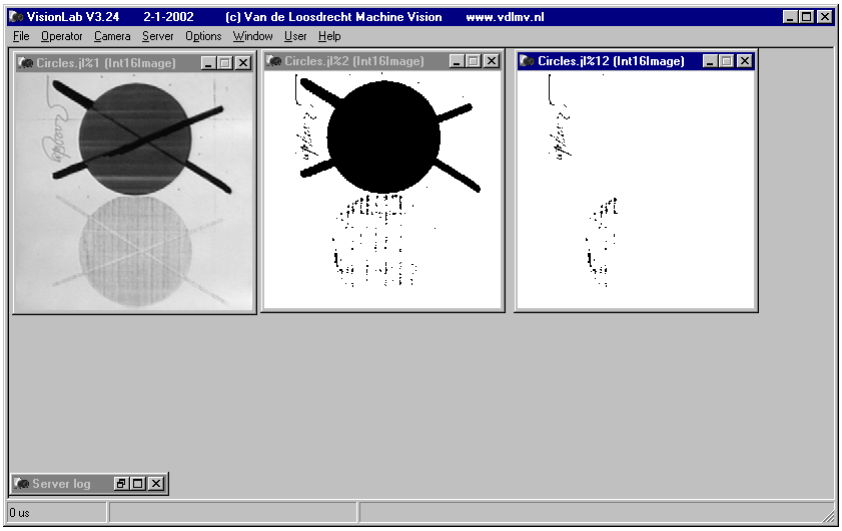
Grayscale Remove Blobs (*)

- **Use "second image" grayscale image for extra grayscale measurements for each blob.**

Demonstration RemoveBlobs

- **Open image circles.jl**
- **Threshold 0 130**
- **RemoveBlobs EightConnected CentreOfGravity 101 32000 UseX**

Demonstration RemoveBlobs



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Remove Blobs Expression

RemoveBlobsExp (image, connected, expression, [modifier])

This operator is similar to RemoveBlobs but uses a regular expression to specify which blobs must be removed

The following operators are supported: and or ! == != < <= > >=

== != < <= > >= are dyadic operators, both parameters are interpreted as floating point numbers and the result is a boolean

One of the parameters must be the name of a blobanalyse tool

If the blobanalyse tool returns a coordinate, the name must be extended with either .x or .y

The other parameter must be either a constant or a $variable.

Use brackets ( ) for priorities in the expression

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Demonstration Remove Blobs Expression

Example 1:

- **Wanted an image with only blobs with Area in [50 .. 500] or blobs with FormFactor in [0.9 .. 1.1]:**
  (Area >= 50 and Area <= 500) or (FormFactor >= 0.9 and FormFactor <= 1.1)
- **Use De Morgan's Law to specify which blobs to remove:**
  (Area < 50 or Area > 500) and (FormFactor < 0.9 or FormFactor > 1.1)

Example 2:

- **Wanted an image with only blobs with TopLeft.y in [50 .. 150]:**
  (TopLeft.y >= 50) and (TopLeft.y <= 150)
- **Use De Morgan's Law to specify which blobs to remove:**
  (TopLeft.y < 50) or (TopLeft.y > 150)

Demonstration Remove Blobs Expression

Example 1 of using Area and FormFactor:

- **Open image cells.jl**
- **ThresholdIsodata image BrightObject**
- **$areaLow = 50**
- **$areaHigh = 500**
- **$exp = "((Area < $areaLow) or (Area > $areaHigh)) and ((FormFactor < 0.9) or (FormFactor > 1.1))"**
- **RemoveBlobsExp image EightConnected &$exp UseX**

Example 2 of using coordinates of TopLeft:

- **Open image cells.jl**
- **ThresholdIsodata image BrightObject**
- **$exp = "((TopLeft.y < 50) or (TopLeft.y > 150))"**
- **RemoveBlobsExp image EightConnected &$exp**

- **Use script RemoveBlobsExp.jls**

Remove Labels (*)

RemoveLabels (image, blobanalyse, low, high, xory, [modifier])

This operator removes blobs in a labelled image with name imageName. All blobs are measured according to the blobanalyse tool chosen and the blobs with measurement result in the range [low..high] are removed from imageName.

The parameter xory is used if blobanalyse specifies a tool which measures a co-ordinate. This parameter specifies whether the x or the y of the co-ordinate is used for the result of the operation.

There is also a RemoveLabelsExp operator

Grayscale Remove Labels [Exp] (*)

- **Use "second image" grayscale image for extra grayscale measurements for each blob.**

Exercise BlobAnalyse

- **Use image drainage.jl**
- **Try to find the "miss printed" holes**

- **answer: drainage.jls**

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Blob And (*)

BlobAnd (image, maskImage, connected)

The original (binary) image is Anded pixel by pixel with the (binary) maskImage. This operator produces a binary image in which the complete blobs of the original image are present for which one or more pixels where left in above mentioned And operation.

The parameter connected has the value EightConnected or FourConnected and determines how the blobs are connected.

A synonym for this operation is region growing.

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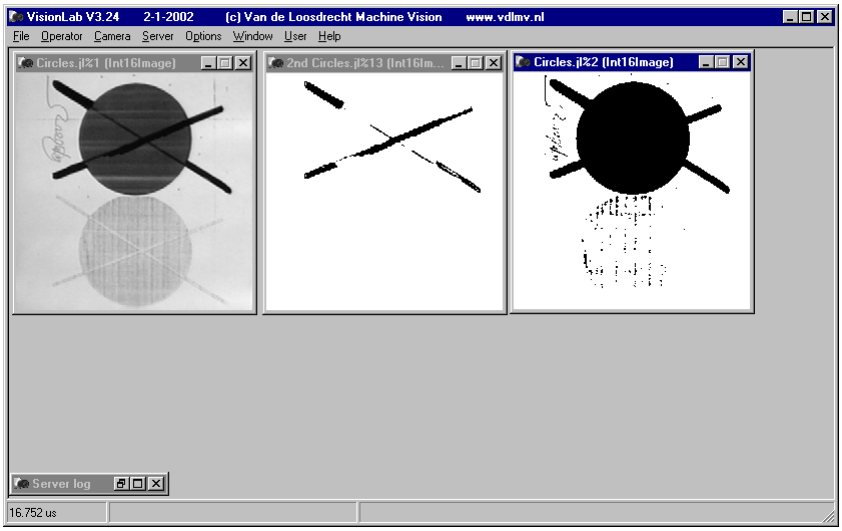
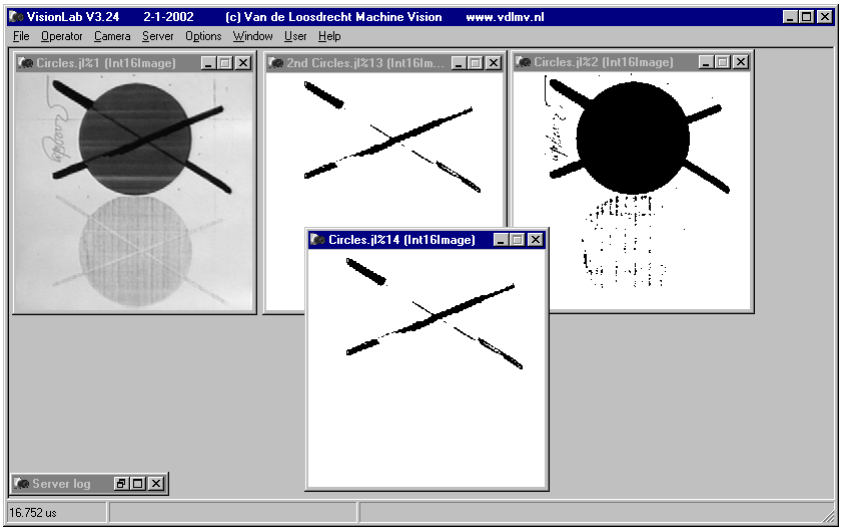
Demonstration Blob And (*)

- **Open image circles.jl**
- **Threshold t130 0 130**
- **Threshold t40 0 40**
- **Compare:**
  - **And t130 t40**
  - **BlobAnd t130 t40 EightConnected**

Threshold 0 40 Threshold 0 130 (*)



And t130 t40 (*)



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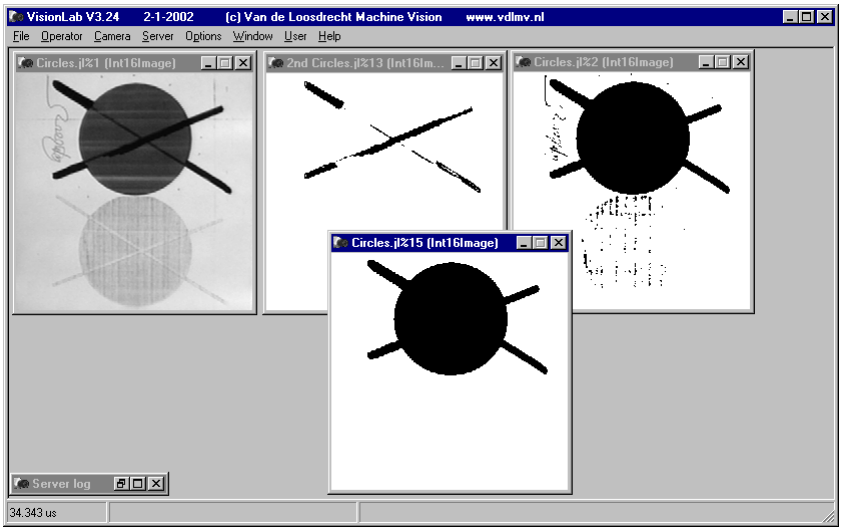
BlobAnd t130 t40 EightConnected (*)



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Find/Fill Holes

FindHoles (image, connected)

This operator find the holes in blobs in binary images. The parameter connected has the value eight-connected or four-connected and determines how the holes are connected.

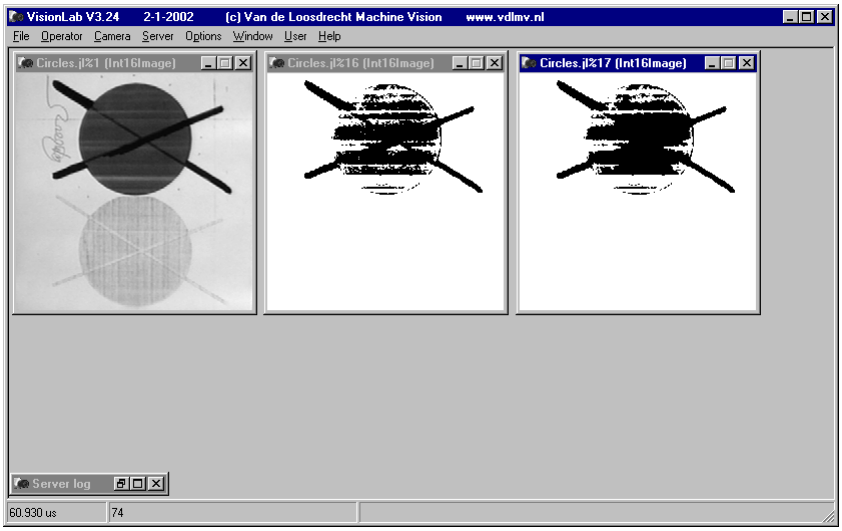
FillHoles (image, connected)

This operator fills the holes in blobs in binary images. The parameter connected has the value eight-connected or four-connected and determines how the holes are connected.

Demonstration Find/Fill Holes

- **Open image circles.jl**
- **Threshold 0 60**
- **FillHoles FourConnected, note result is number of holes**
- **FindHoles FourConnected**

FillHoles FourConnected



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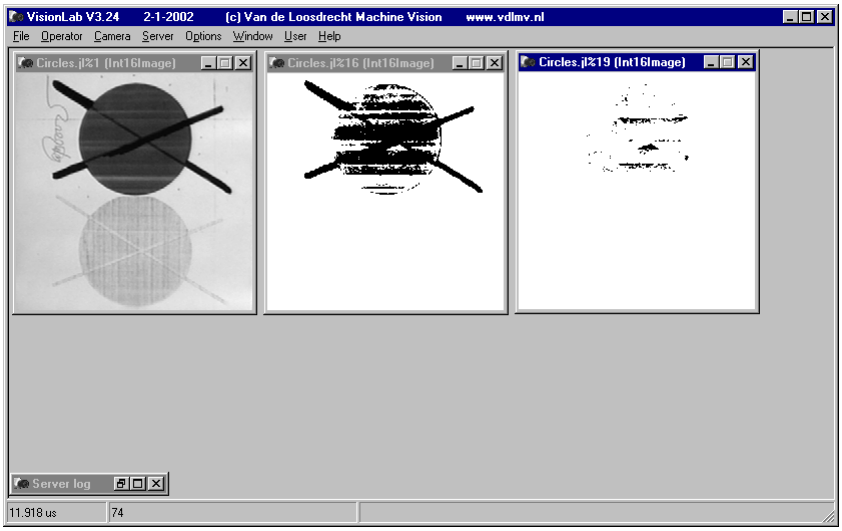
FindHoles FourConnected



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Find/Fill Specific Holes

FindSpecifHoles (image, connected, blobanalyse, low, high, xory, [modifier])

FillSpecifHoles (image, connected, blobanalyse, low, high, xory, [modifier])

This operator find/fill the specified holes in blobs in binary images.

The parameter connected has the value eight-connected or four-connected and determines how the holes are connected.

The holes are specified with the blobanalyse tool chosen and the measurement in the range [low..high].

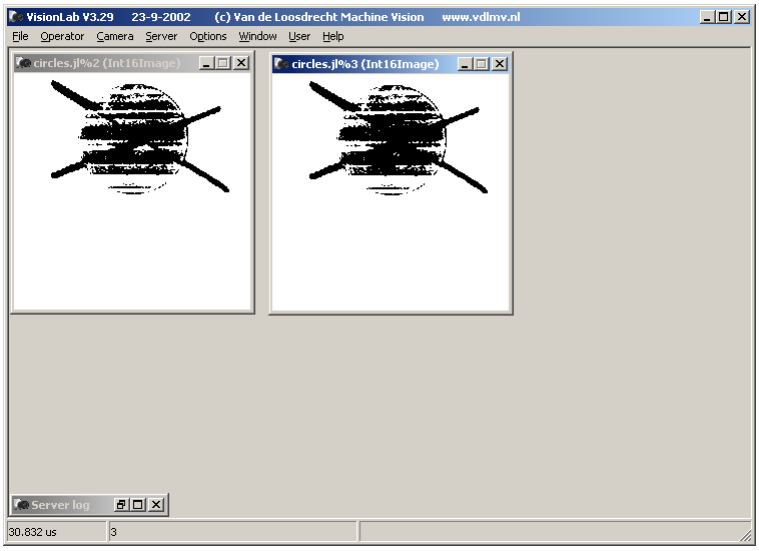
The parameter xory is used if the blobanalyse tool specifies a tool which measures a co-ordinate. This parameter specifies whether the x or the y of the co-ordinate is used for the result of the operation.

Also GrayscaleFindSpecifHoles and GrayscaleFillSpecifHoles.

Demonstration Find/Fill Specific Holes

- **Open image circles.jl**
- **Threshold 0 60**
- ***FillSpecifcHoles*** **FourConnected Area 50 300 UseX, note result is number of holes**
- ***FindSpecificHoles*** **FourConnected Area 50 300 UseX**

Fill Specific Holes Area 50 300



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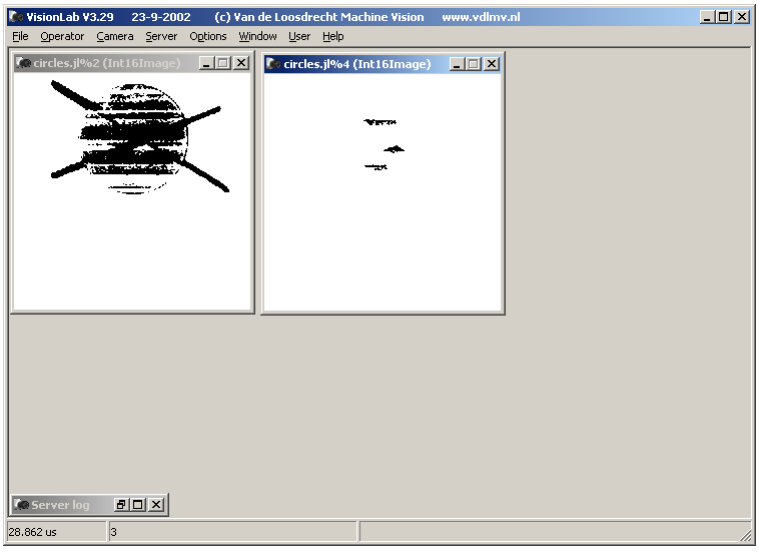
Find Specific Holes Area 50 300



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Remove Border Blobs

RemoveBorderBlobs (image, connected, borders)

This operator removes all blobs from a binary image which touch the specified borders of the image. The parameter connected has the value EightConnected or FourConnected and determines how the blobs are connected.

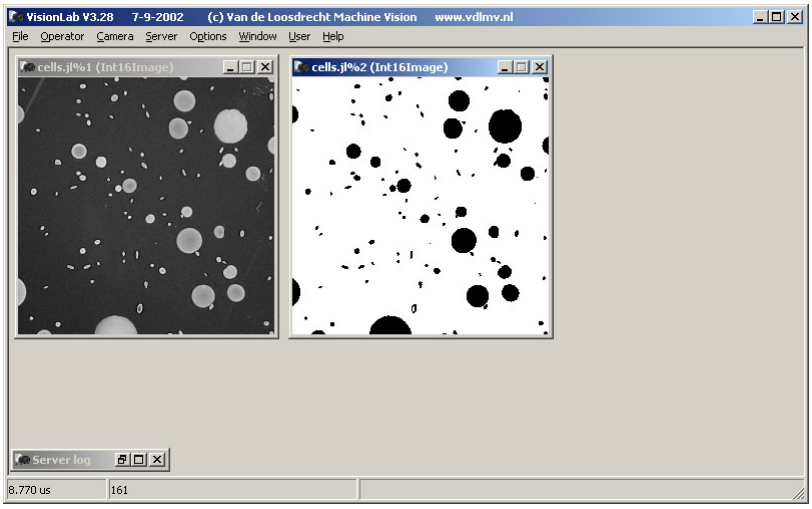
The parameter borders can have one of the following values: AllBorders, LeftBorder, RightBorder, TopBorder, BottomBorder, LeftAndTopBorder, TopAndRightBorder, RightAndBottomBorder or BottomAndLeftBorder.

Usage: correcting counts of objects touching the borders

Demonstration Remove Border Blobs

- **Open file cells.jl**
- **ThresholdIsoData BrightObject**
- **RemoveBorderBlobs EightConnected AllBorders**
- **RemoveBorderBlobs EightConnected LeftAndTopBorder**

ThresholdIsoData



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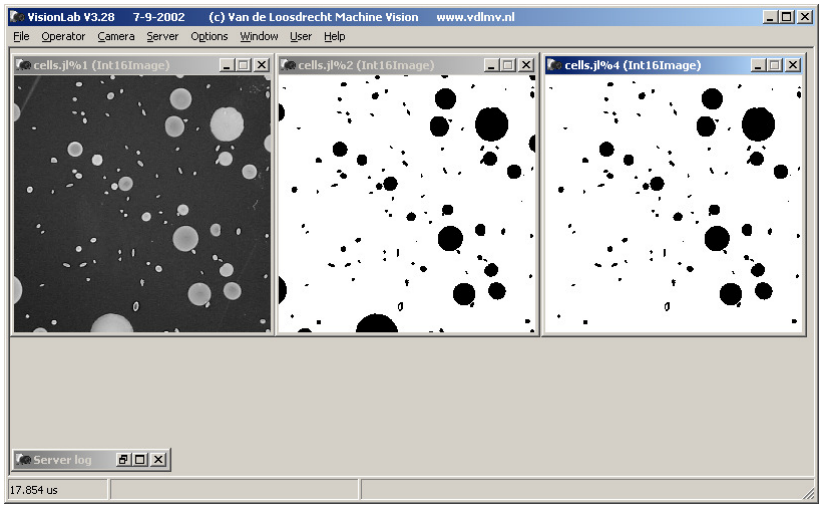
RemoveBorderBlobs EightConnected AllBorders



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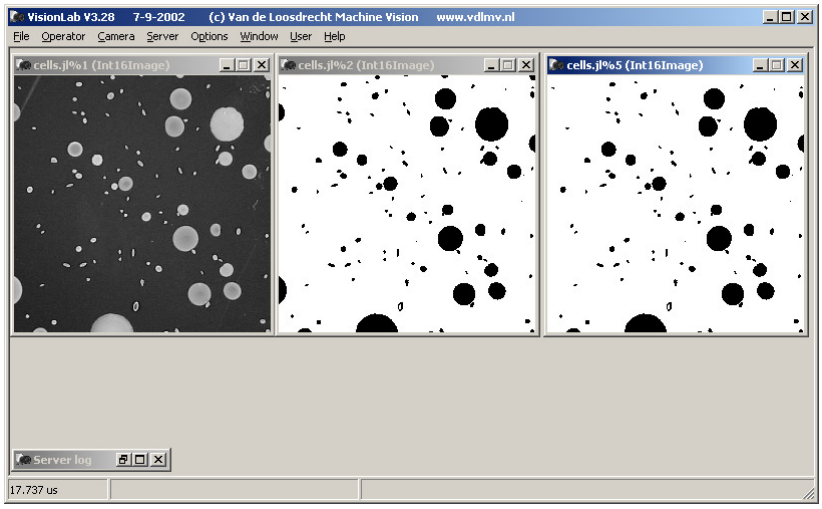
RemoveBorderBlobs EightConnected LeftAndTopBorder



Exercise Remove Border Blobs (*)

- **Write a script for the Remove Border Blobs operator**
- **Hints:**
  - **Use image cells.jl for testing**
  - **Use BlobAnd operator**
  - **In the Operator | Synthetic menu are handy operators to generate artificial (mask) images**

- **answer: script removeborder.jls**

Demonstration measuring edge touching blobs (*)

Problem:

Edge touching blobs can not be measured reliable, because small blobs are included disproportionate

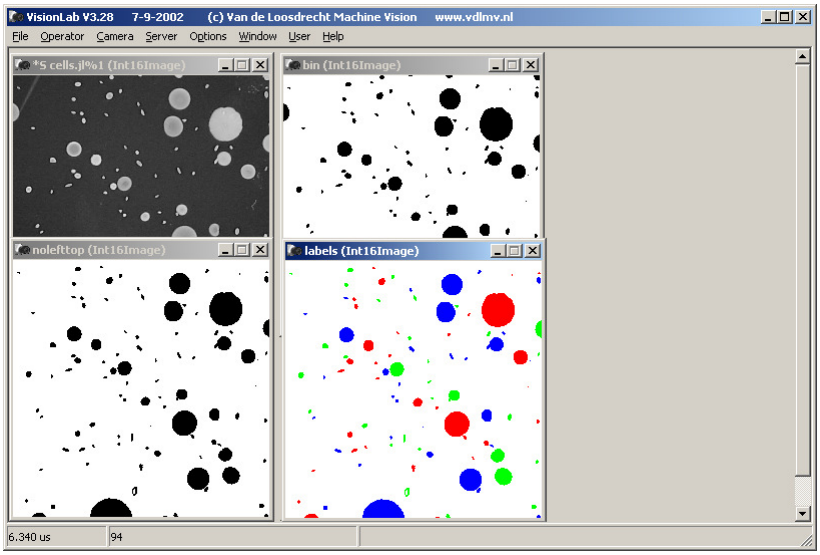
Practical examples:

- **Counting number of objects in field of view**
- **Size distribution of objects in field of view**

Counting number of objects in field of view (*)

- **Use script: countcells.jls**
  - **open image cells.jl**
  - **thresholdisodata BrightObject**
  - **removeborderblobs EightConnected LeftAndTopBorder**
  - **labelblobs EightConnected**
    (function result is nr of blobs)

Counting number of objects in field of view (*)

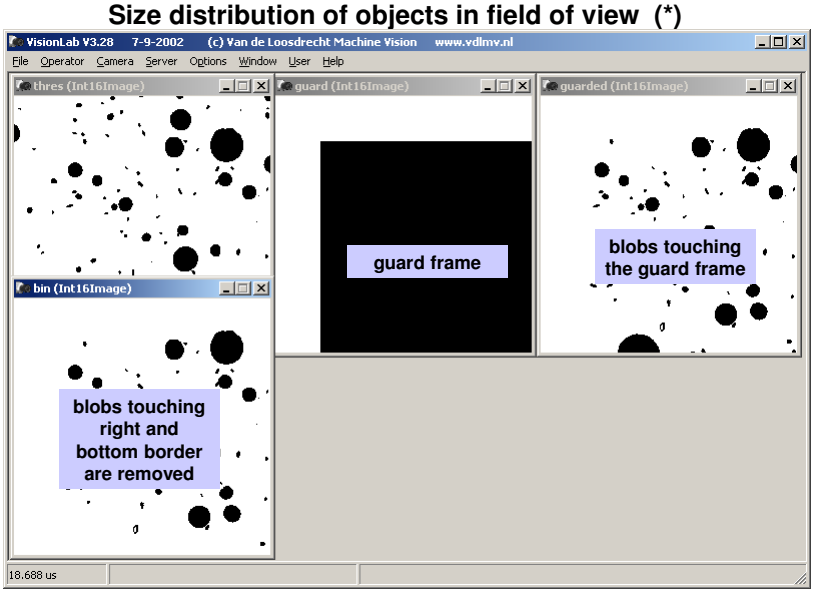


Size distribution of objects in field of view (*)

Idea: use a guard frame

- **a guard frame is generated touching right and bottom border**
- **guard frame is BlobAnded with blobs**
- **blobs touching right border and bottom border are removed**
- ***in top and left border of result are on average the same distribution of blobs as in right and bottom border***
- **top and left border blobs are counted**
- **right and border blobs are discarded**

Size distribution of objects in field of view (*)



Size distribution of objects in field of view (*)

- Open image cells.jl
- Use script distribcells.jls, *its better to give a 'life performance'*
  - lread org cells.jl
  - display org
  - copy org bin
  - thresholdisodata bin BrightObject
  - display bin
  - copy bin label
  - labelblobs label EightConnected
  - blobanalysis label SortUp Length UseX Area Length
  - // biggest blob has length < 42, see server log
  - break

  - copy bin guard
  - blockpattern guard 45 45 200 200 1 20 20 (use image bin)
  - setlut guard Binary
  - display guard
  - break

Size distribution of objects in field of view (*)

- **bloband bin guard EightConnected** (Segmentation Menu)
- **display bin**
- **break**

- **removeborderblobs bin EightConnected RightAndBottomBorder**
- **display bin**
- **break**

- **copy bin label**
- **labelblobs label EightConnected**
- **setlogmode LogCSV**
- **blobanalysisheadertxt Area Breadth Length Perimeter**
- **llastanswertologfile cells.csv <cr/lf>**
- **blobanalysis label SortUp Area UseX Area Breadth Length Perimeter**
- **llastanswertologfile cells.csv <cr/lf>**

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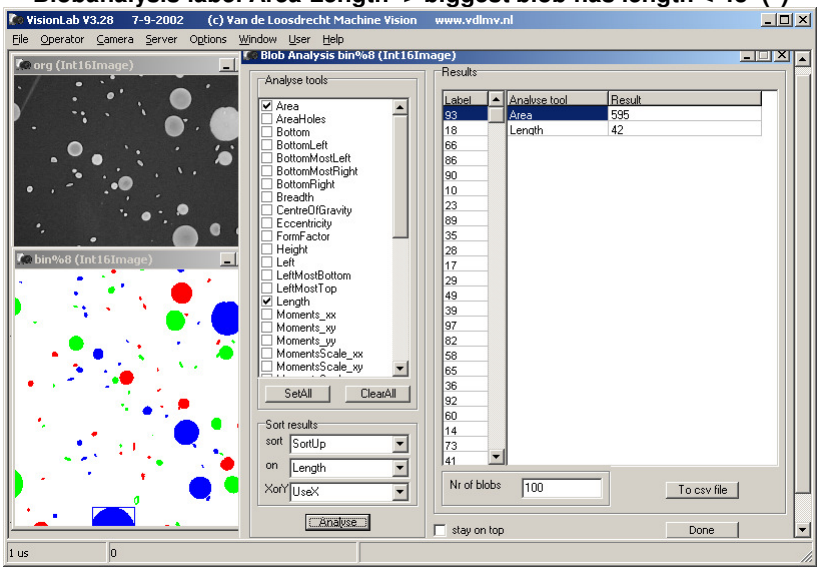
Blobanalysis label Area Length -> biggest blob has length < 43 (*)



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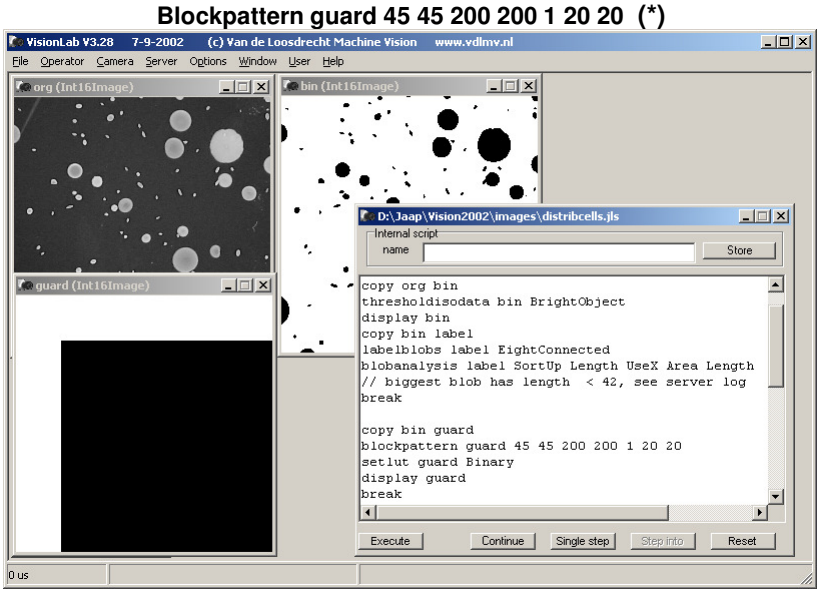
Blockpattern guard 45 45 200 200 1 20 20 (*)



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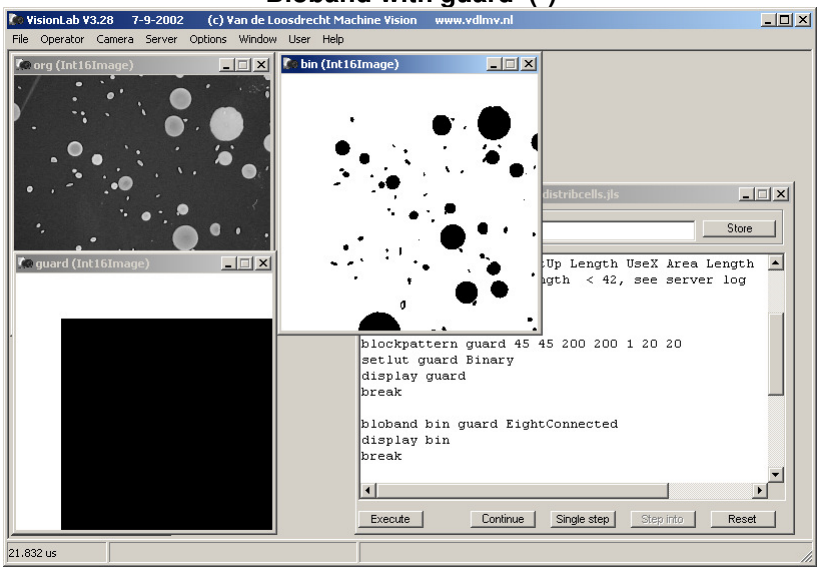
Bloband with guard (*)



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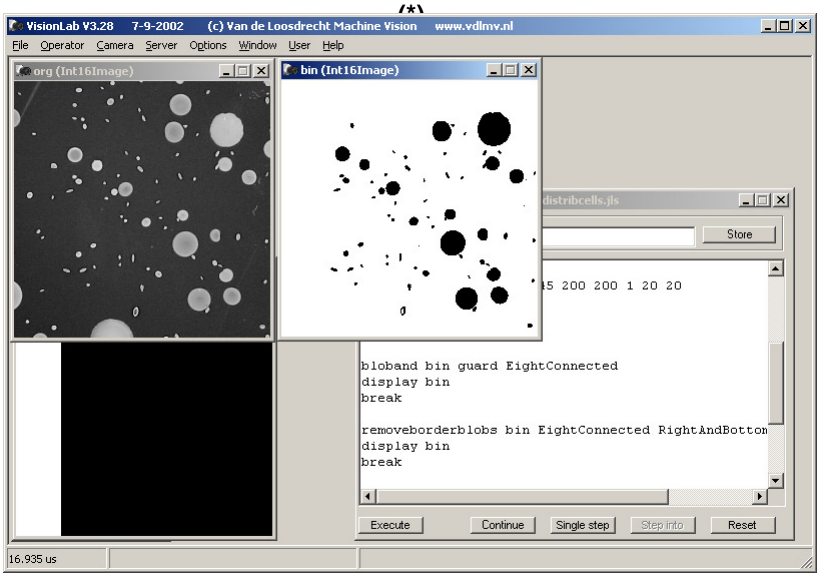
Removeborderblobs EightConnected RightAndBottomBorder (*)



Final result in spread sheet (*)

Microsoft Excel - cells.csv

Bestand Bewerken Beeld Invoegen Opmaak Extra Data Venster Help

A1 = Label

	A	B	C	D	E
1	Label	Area	Breadth	Length	Perimeter
2					
3	1	898	34.0151	35.0588	104.675
4	39	512	26.632	31.0832	88.48
5	61	410	23.2036	27.4008	76.393
6	2	313	20.4165	21.6155	60.198
7	60	236	18.0294	18.8045	52.851
8	6	175	14.9284	15.8661	44.24
9	12	168	14.9284	18.72	48.269
10	15	166	14.6015	14.6015	42.66
11	25	160	14.6015	15.2127	42.897
12	54	144	13.2066	13.8062	40.448
13	38	103	10	12	32.943
14	32	100	12.6619	13.53	36.182
15	13	94	10	11	31.6
16	34	63	8.61577	9.94427	26.149
17	26	35	7	7	18.881
18	55	32	6.38516	7.32456	16.985
19	21	31	6.38516	7.32456	16.985
20	62	28	6	10.8489	19.987
21	44	25	6.09902	7.08276	14.852
22	47	21	4.60555	6	13.509
23	40	21	5	7.7082	14.299