



Computer Vision

Segmentation

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Segmentation

Overview:

- **Threshold**
 - **Manual**
 - **Automatic**
- **SeparateBlobs**
- **Watershed**
- **Robust Automatic Threshold Selection (RATS) ***

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Threshold Manual

- Threshold
- Threshold Tool
- Threshold Local (*)
- Threshold Hysteresis

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Threshold (manual)

Threshold (image, low, high)

The threshold operator takes a greyscale image and produces a binary image.

If $\text{low} \leq \text{high}$ then all pixel values in the range $[\text{low}..\text{high}]$ are converted to the value Object (=1) and all other pixel values are converted to the value Background (=0).

If $\text{low} > \text{high}$ then all pixel values not in the range $(\text{high}..\text{low})$ are converted to the value Object and all other pixel values are converted to the value Background.

Usage: information reduction

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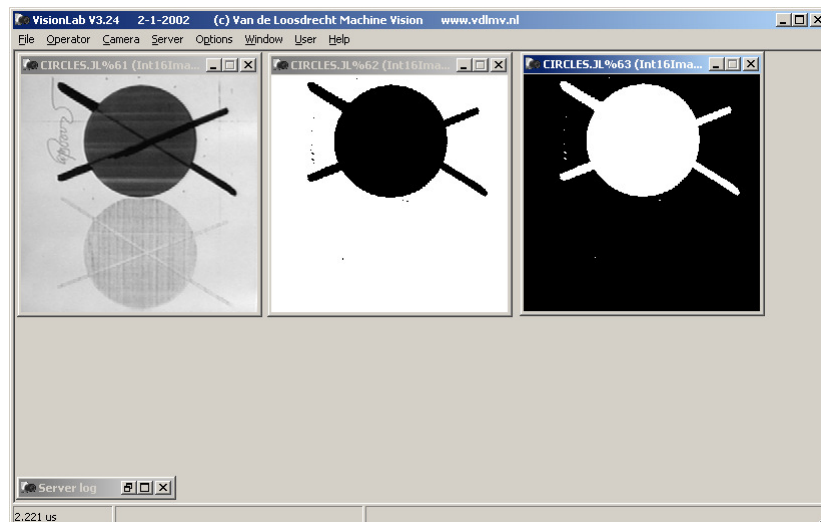
Demonstration Threshold (manual) (*)

- Open image circles.jl
- Threshold image 0 120
- Threshold image 120 0
- Invert (Threshold 120 0) != Threshold 0 120, demonstrate with Difference operator
- Invert (Threshold 121 -1) = Threshold 0 120, idea: border belongs to object

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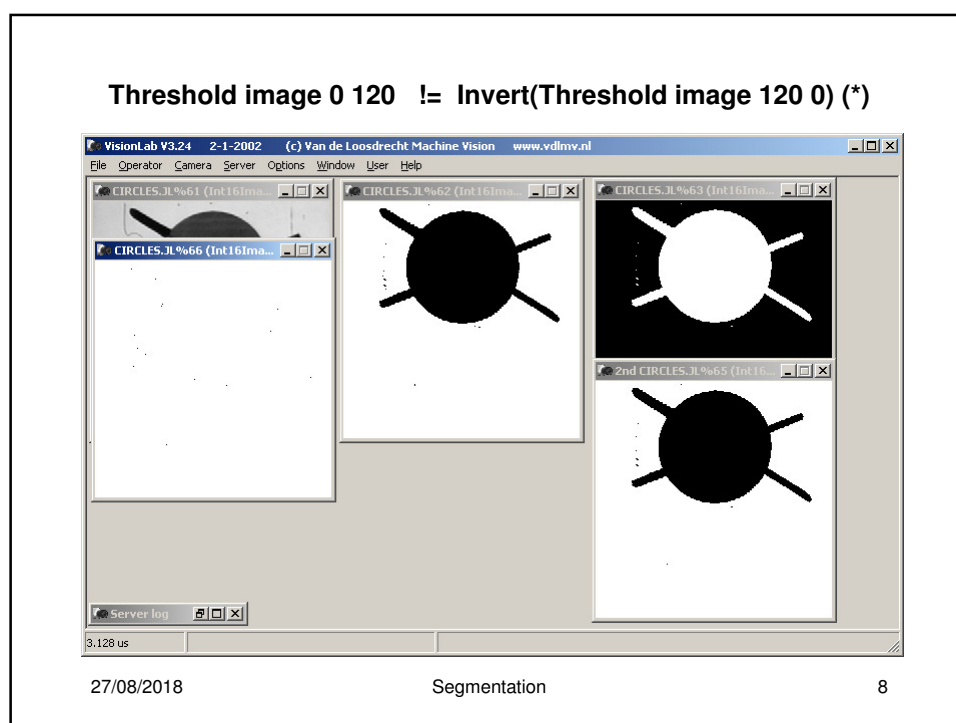
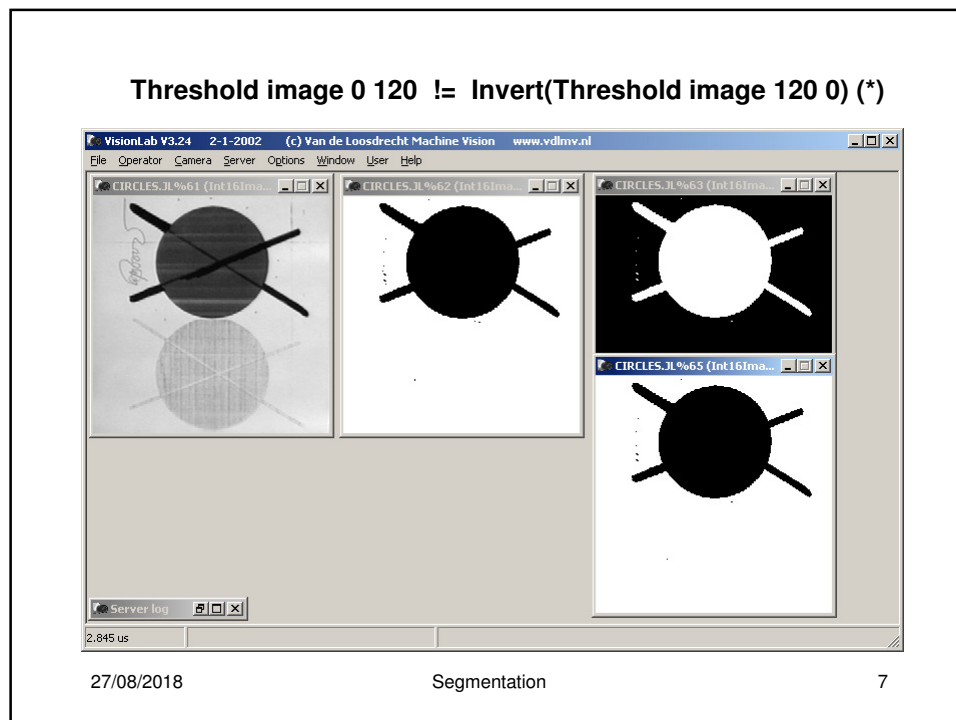
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Threshold image 0 120 Threshold image 120 0 (*)

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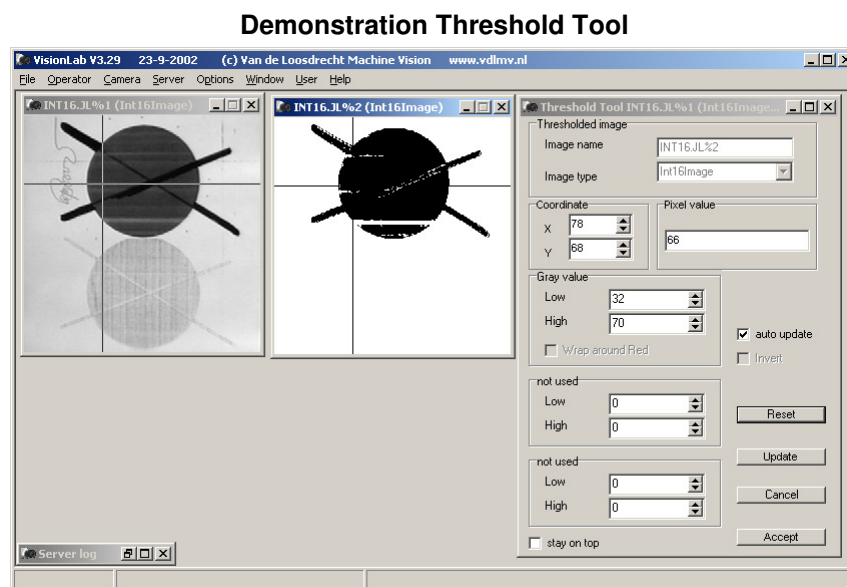
Threshold Tool

With this tool you can threshold interactively an image by selecting the object pixels with the mouse cursor

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Special manual threshold operators

- **ThresholdSimple** (image, thres, bright|dark)
- **ThresholdFast** (image, low, high, min, max)
- **ThresholdMulti** (image, th₁, th₂, ... ,th_n)
- **ThresholdOnHighest** (image)
- **ThresholdOnLowest** (image)
- **ThresholdOnLowestButZero** (image)

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Demonstration Threshold (manual) (*)

- Open image circles.jl (no slides for example)
- **ThresholdSimple** 120 DarkObject
- **ThresholdFast** 0 120 0 255, uses LUT, is faster then normal threshold
- Open image circles.jl
- **Threshold** 0 120
- **LabelBlobs** EightConnected
- **BlobAnalysis** Area Height TopLeft Width
- **ThresholdMulti** 2 7 8, in order to select the 3 biggest objects

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After BlobAnalysis (*)

The screenshot shows the VisionLab V3.24 interface. On the left, there are two image windows: 'CIRCLES.JL%61 (Int16Image)' showing a grayscale image of a circle with a black cross, and 'CIRCLES.JL%68 (Int16Image)' showing the same circle with a green fill and a blue bounding box. In the center, the 'Blob Analysis CIRCLES.JL%68 (Int16Image)' window is open, displaying a list of analysis tools on the left and a results table on the right. The 'Width' tool is selected. The results table shows the following data:

Label	Analyse tool	Result
2	Area	11275
7	Height	115
8	TopLeft	{36,7}
11	Width	180

At the bottom of the interface, the date '27/08/2018' is displayed on the left, the word 'Segmentation' is in the center, and the number '13' is on the right.

ThresholdMulti 2 7 8 (*)

The screenshot shows the VisionLab V3.24 interface with four image windows arranged in a 2x2 grid. The top-left window 'CIRCLES.JL%61 (Int16Image)' shows a grayscale image of a circle with a black cross. The top-right window 'CIRCLES.JL%67 (Int16Image)' shows the same circle with a black fill and a blue bounding box. The bottom-left window 'CIRCLES.JL%68 (Int16Image)' shows the same circle with a green fill and a blue bounding box. The bottom-right window 'CIRCLES.JL%69 (Int16Image)' shows the same circle with a black fill and a blue bounding box. At the bottom of the interface, the date '27/08/2018' is displayed on the left, the word 'Segmentation' is in the center, and the number '14' is on the right.

Demonstration Threshold (manual) (*)

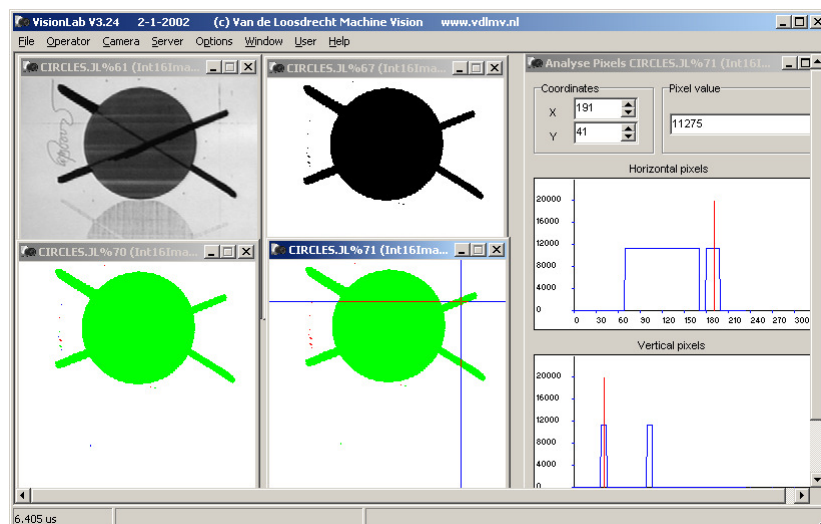
- Open image circles.jl
- Threshold 0 120
- LabelBlobs EightConnected
- BlobMeasure Area 100 UseX, label number is replaced by area of blob
- ThresholdOnHigest, selects largest object
- ThresholdOnLowestButZero, selects smallest object

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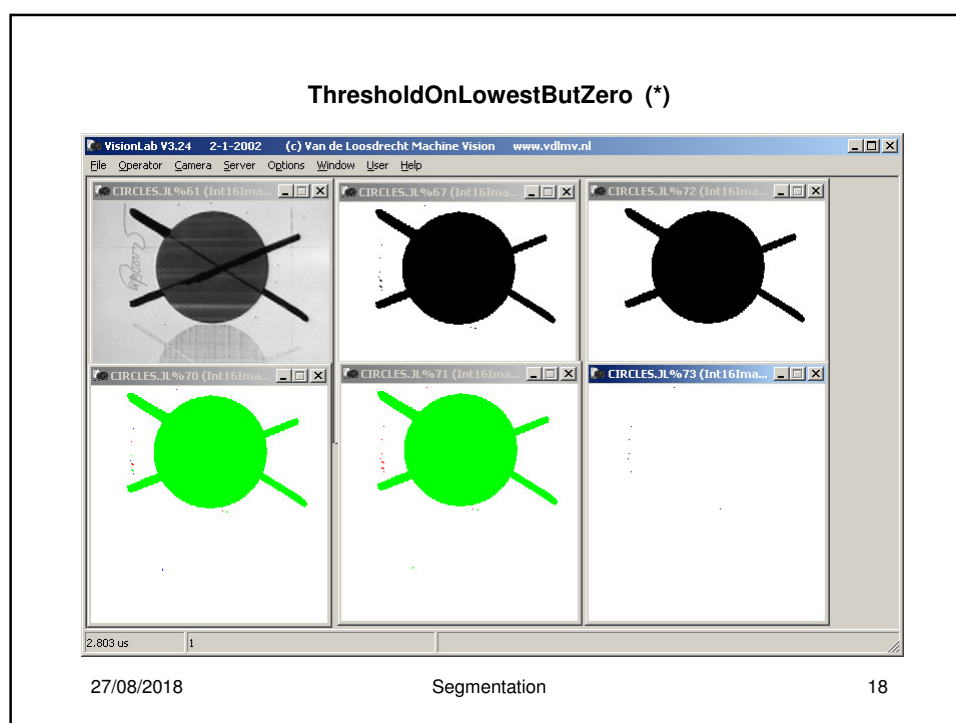
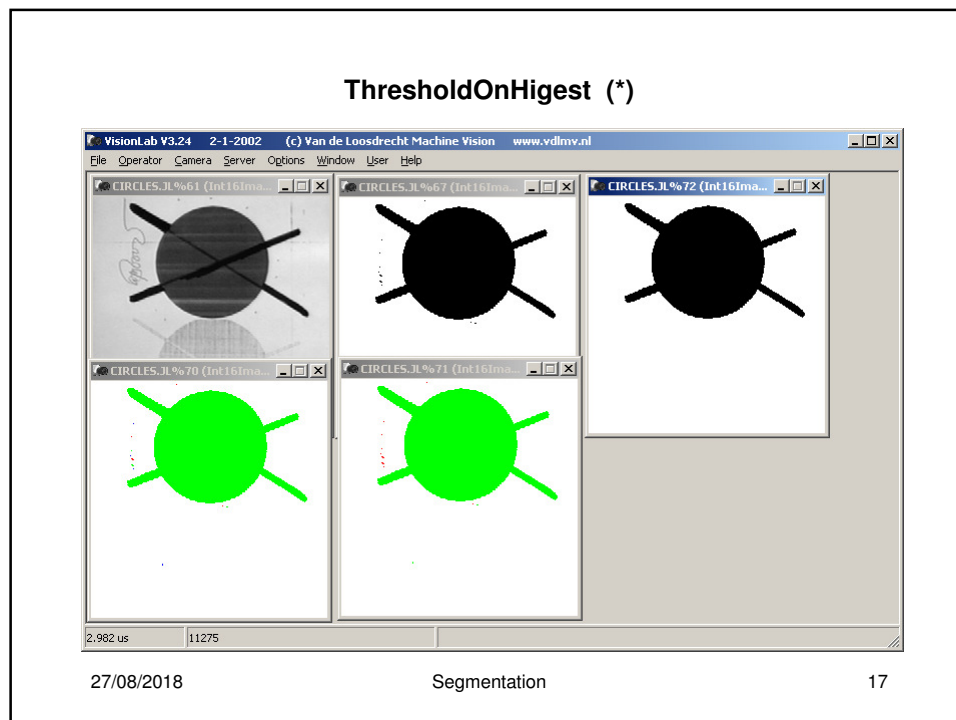
BlobMeasure Area (*)



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Threshold Local (*)

ThresholdLocal (image, mask, bright|dark)

This operator uses the pixel values in the mask image as an individual threshold value for each pixel the image.

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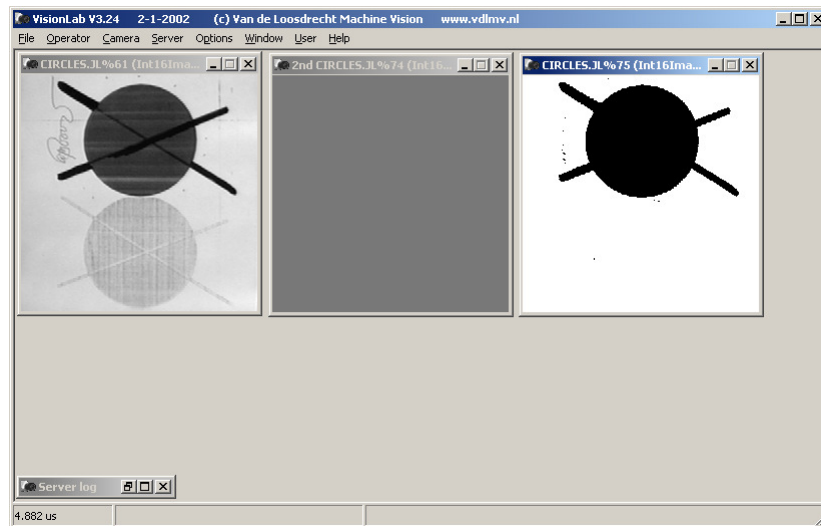
Demonstration Threshold Local (*)

- Open image circles.jl
- SetAllPixels 120
- Select as 2nd image
- ThresholdLocal circles.jl 2ndImage, used later for dynamic thresholds

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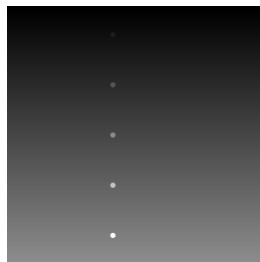
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ThresholdLocal with mask image with value 120 everywhere (*)

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Exercise Threshold local (*)

- Use image backsubdiv.jl in the images directory
- Use analyse pixel to analyse image
- Generate a suitable mask image using ramp pattern in Operator|Synthetic menu
- See threslocal.jls for answer

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Threshold Hysteresis

ThresholdHysteresis (image low high connected)

The thresholdhysteresis operator takes a greyscale image and produces a binary Image.

If $\text{high} \geq \text{low}$ then all pixels with a value greater than high are selected as object pixels. These object pixels are used as seeds. All connected neighbours of the seeds with a pixel value greater than low are added to the object pixels. This growing process is repeated until no pixels are added.

If $\text{high} < \text{low}$ then all pixels with a value smaller than high are selected as object pixels. These object pixels are used as seeds. All connected neighbours of the seeds with a pixel value smaller than low are added to the object pixels. This growing process is repeated until no pixels are added.

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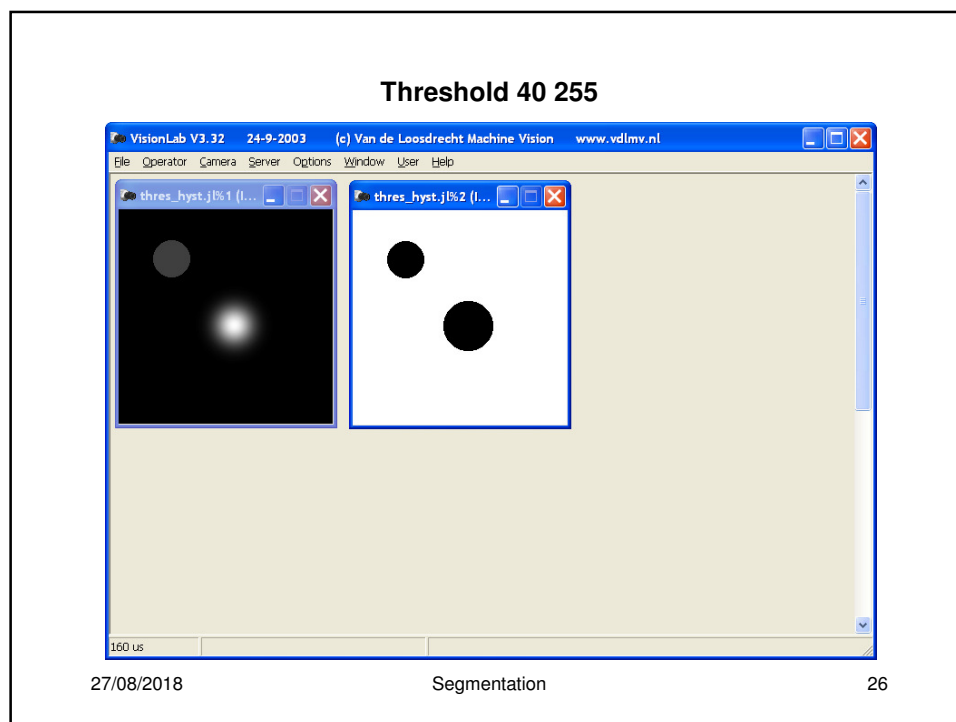
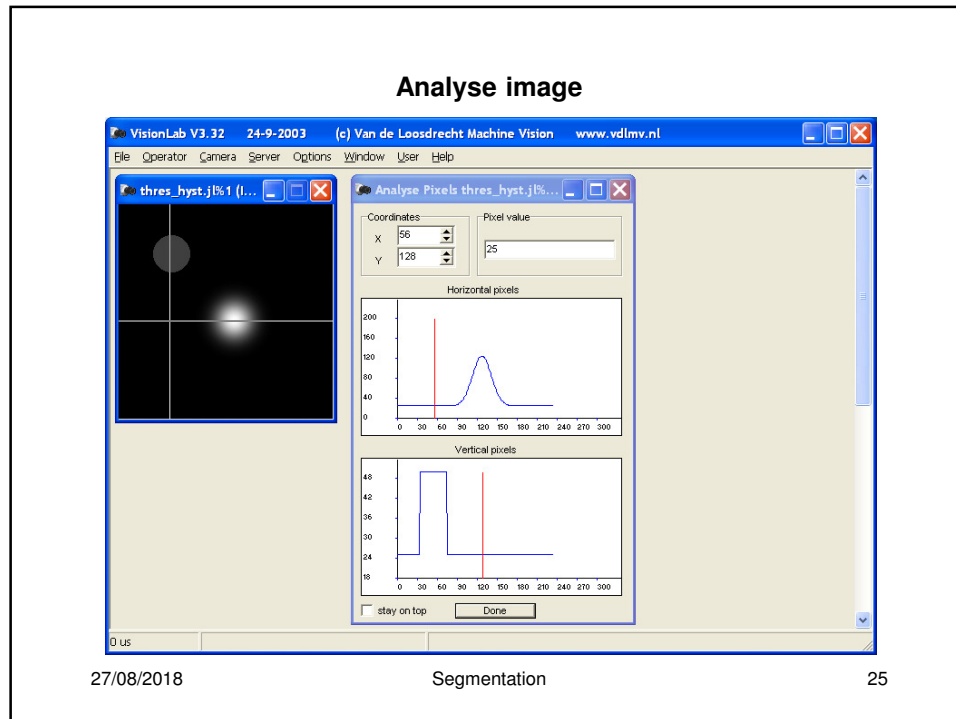
Demonstration Threshold Hysteresis

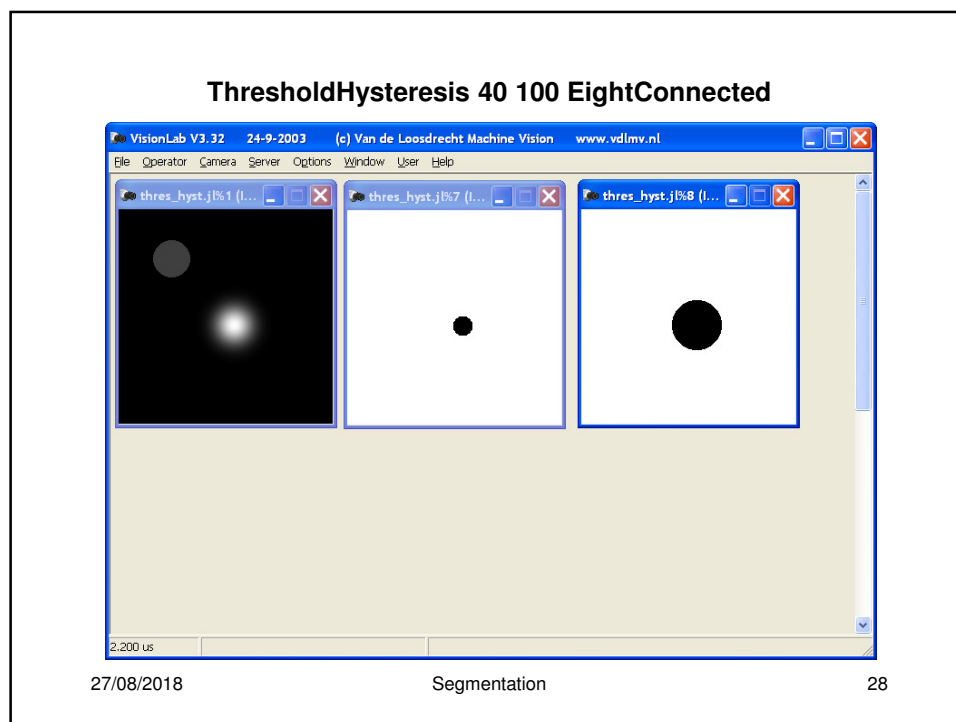
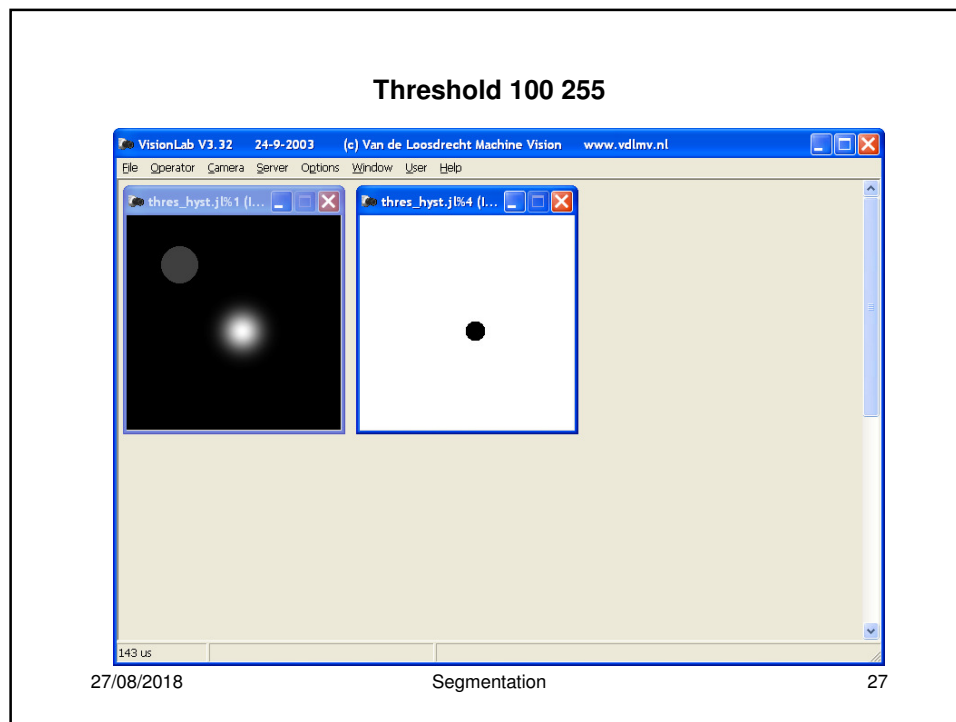
- Open image `thres_hyst.tif`
- Analyse image with analyze pixels:
 - background = 25
 - left disk = 50
 - right disk = [40 .. 125]
- Problem: select complete right disk only
- Threshold image 40 255, gives both disks
- Threshold image 100 255, gives right disk but it is too small
- ThresholdHysteresis 40 100 EightConnected

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Automatic Thresholding

- **Threshold Iso Data**
- **Robust Automatic Threshold Selection (RATS) ***
- **Local RATS ***

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Threshold Iso Data

ThresholdIsoData (image, bright|dark)

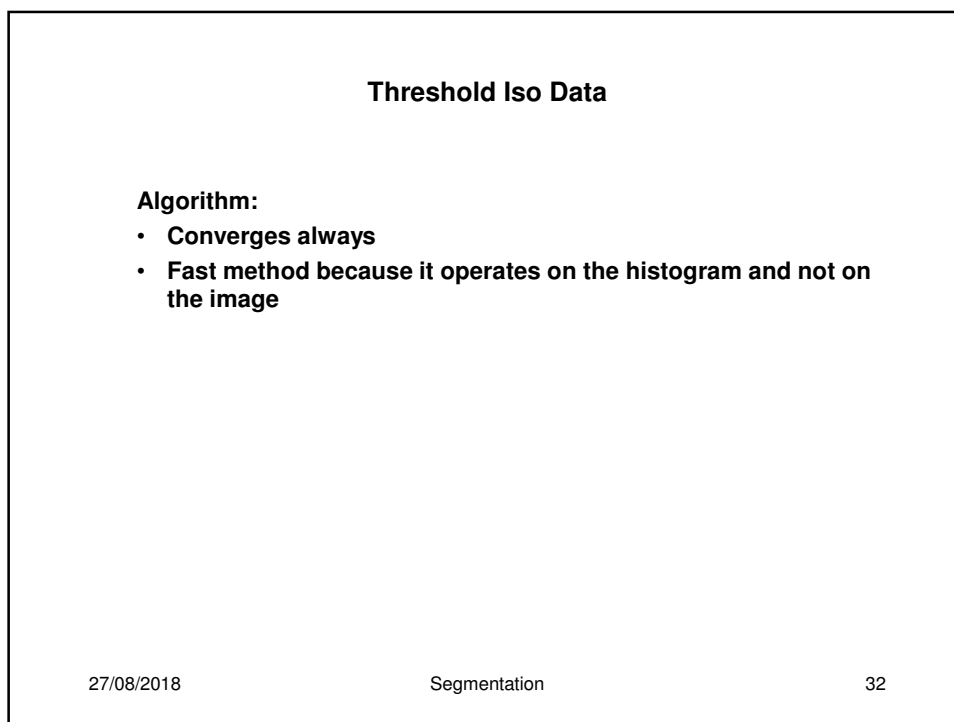
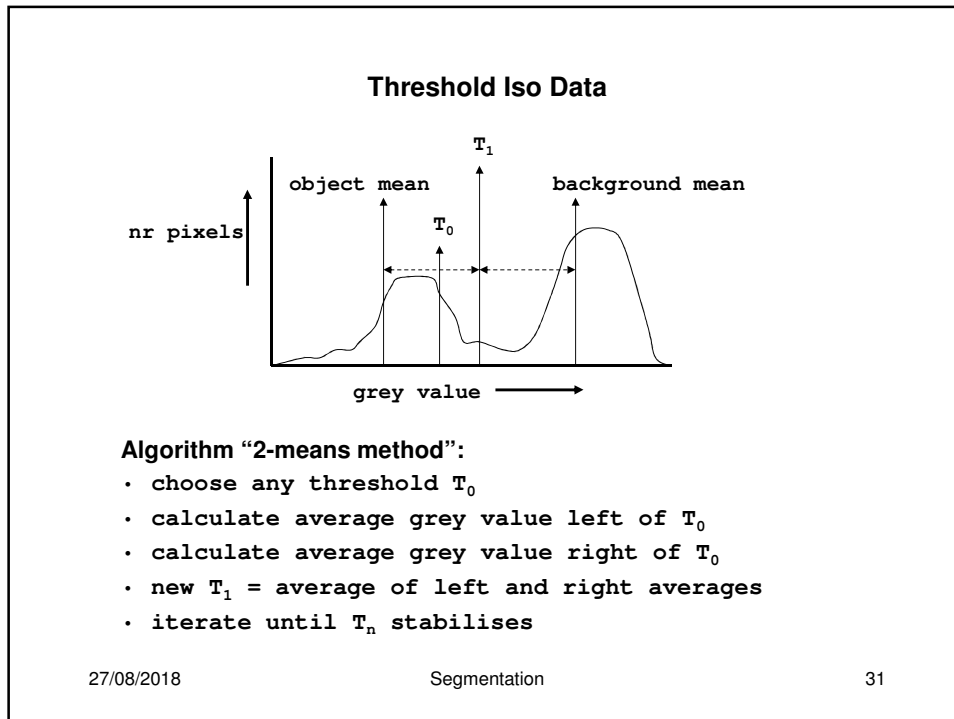
idea:

- **works good if histogram has a bi-modal distribution**
- **try to find the middle between the bumps**

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Demonstration Threshold Iso Data

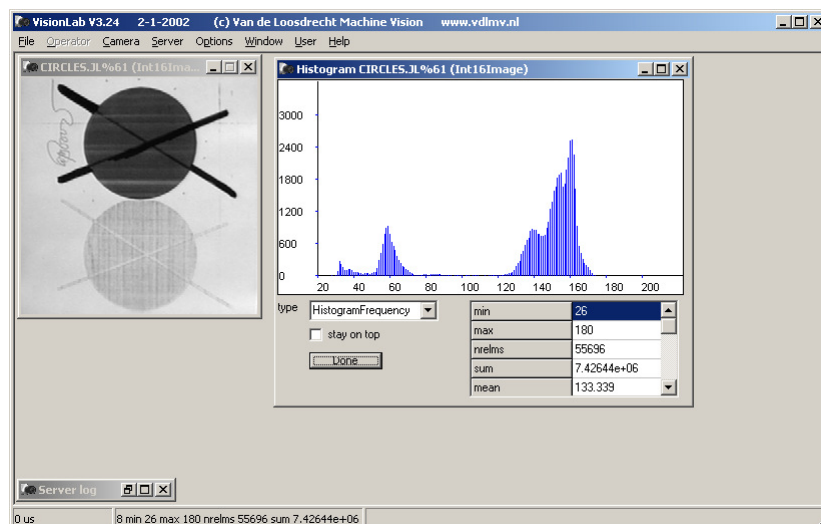
- Open image circles.jl
- Show frequency histogram, show binomial distribution
- ThresholdIsoData DarkObject, note chosen threshold is returned

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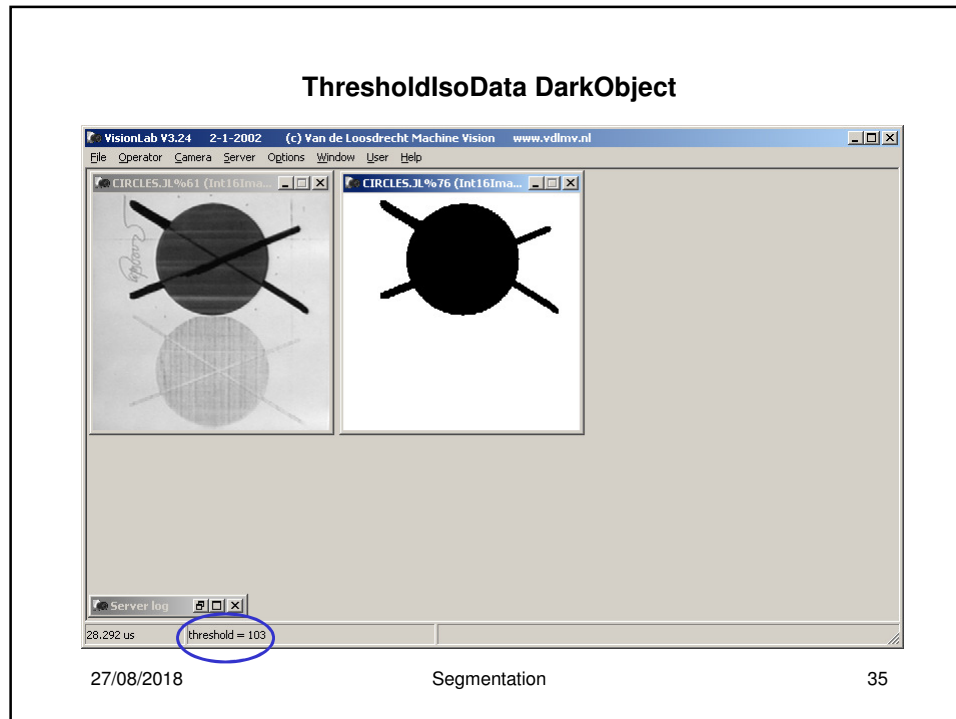
Frequency histogram, bi-modal distribution



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Separate Blobs

SeparateBlobs (srcImage, destImage, size)

This operator separates blobs that are "grown" together.

The size parameter gives the high limit in pixels that is possible for blobs to have overlap in order to be considered two distinct blobs.

Note: all blobs with a height or width smaller then size will be removed from the result.

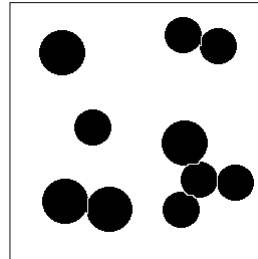
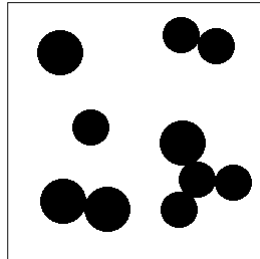
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Demonstration Separate Blobs

- Open image `connectedballs.jl`
- `SeparateBlobs` 20

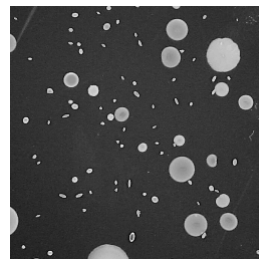


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Exercise Threshold operators



- Experiment with `Threshold`, `ThresholdTool`, `ThresholdIsoData` on images `dice.jl` and `cells.jl`

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Watershed

Watershed (srcImage, destImage, first, last, coreLimit, minArea)

This operator calculates the watersheds of an image. The destImage has pixel values of -1 at the positions of the watersheds. All pixels belonging to one Eightconnected object have the same positive value.

The parameter first specifies highest object value and last specifies lowest object value in the image. The algorithm can be accelerated by specifying a coreLimit. All connected pixels with values [coreLimit .. first] are considered to belong to the same object. This acceleration is not used when coreLimit = first. The parameter minArea specifies the minimal number of pixels that an object must consist of.

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Watershed

In the normal case first > last and the watersheds are found at the low pixel values. It is also possible to find "inverted" watersheds. In this case first < last, connected pixels with values [first .. coreLimit] are considered to belong to the same object and the watersheds are found at the high pixel values.

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Demonstration Watershed

Find potatoes on conveyer belt in depth image

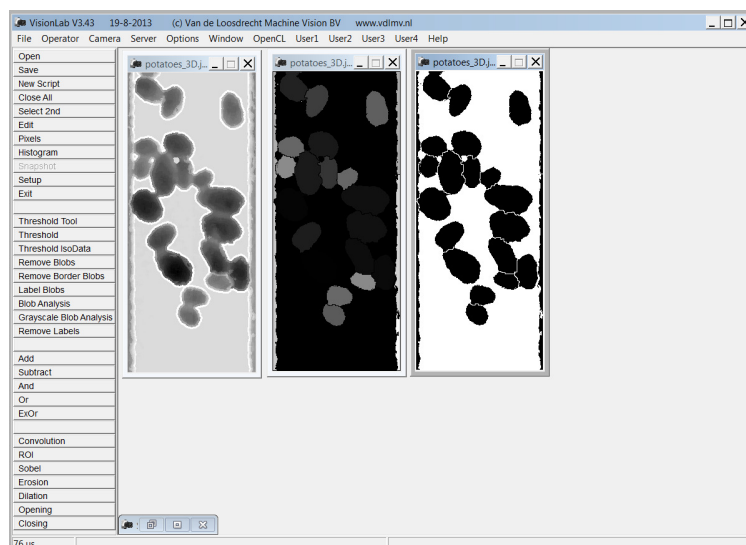
- Open image potatoes_3D.jl
- Watershed p r 788 840 788 250
- ThresholdSimple r 1 BrightObject

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Demonstration Watershed



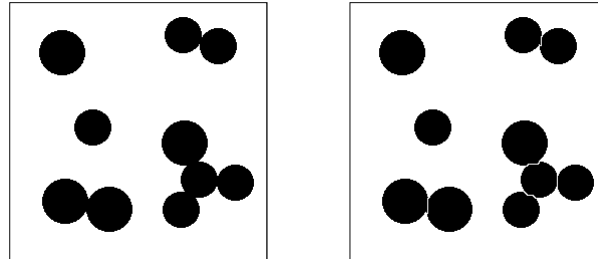
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Exercise Watershed

- Implement script for SeparateBlobs using Watershed and Distance Transform
- Test on image connectedballs.jl



Answer: SeparateBlobs_with_Watershed.jls

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Robust Automatic Threshold Selection (*)

Robust Automatic Threshold Selection

- RATS (image, minEdge)
- ThresholdRATS (image, minEdge, bright|dark)

Idea:

- Find the strong edges in the image
- Chosen threshold value is the weighted mean value of the positions with the strong edges
- "How stronger the edge, the more the pixel value contributes to the calculated value"

$$\text{threshold} = \text{sum}(\text{image} * \text{highEdges}) / \text{sum}(\text{highEdges})$$

NOTE: because of the internal calculations that are performed at least `Int32Images` are necessary to avoid overflow

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Demonstration RATS (*)

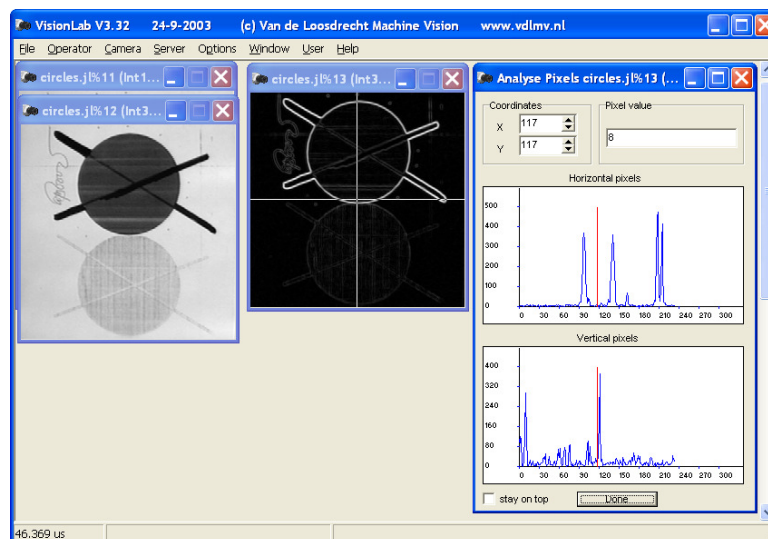
- Convert circles.jl to Int32Image
- First some explanation about edge detection:
 - There will be later a full lecture about edge detection
 - Sobel GradientMagnitude 10000 0, analyse pixels result
 - Threshold 100 10000, to find the strong edges
- RATS circles32.jl 100, returns optimal threshold value
- ThresholdRats circles32.jl 100 DarkObject, executes the threshold operation also. Almost the same result as ThresholdIsoData for this image, but based on a different method (no bi-modale distribution needed).

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Sobel GradientMagnitude 10000 0 (*)

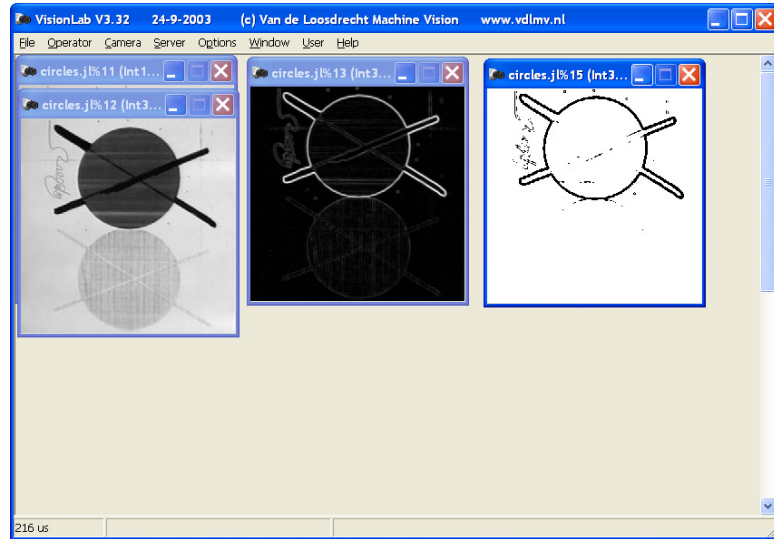


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Threshold 100 10000, to find the strong edges (*)

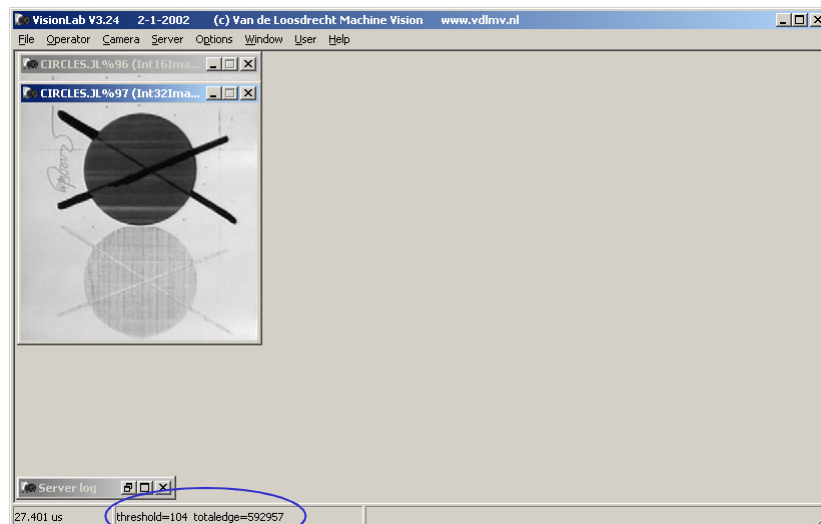


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RATS circles32.jl 100 (after conversion to Int32Image) (*)

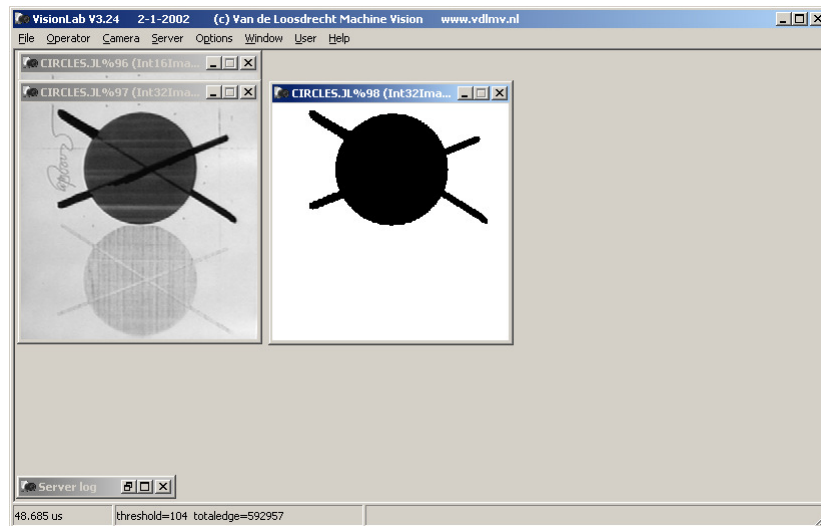


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ThresholdRats circles32.jl 100 DarkObject (*)



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Threshold RATSLocal (*)

Local Robust Automatic Threshold Selection

- RATSLocal (image, mask, minEdge, minAvgEdges, nrLevels)
- ThresholdRATSLocal (image, minEdge, minAvgEdges, nrLevels, bright|dark)

Idea:

- The image is subdivided in small squares, nrLevels deep making a quad tree
- For each square a local threshold is calculated using RATS, If the average edge value in a square is below minAvgEdges, the square inherits the local threshold value of the next higher square in the quad tree.
- With the local threshold values a mask image is build.

NOTE: because of the internal calculations that are performed at least Int32Images are necessary to avoid overflow

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Demonstration RATSLocal (*)

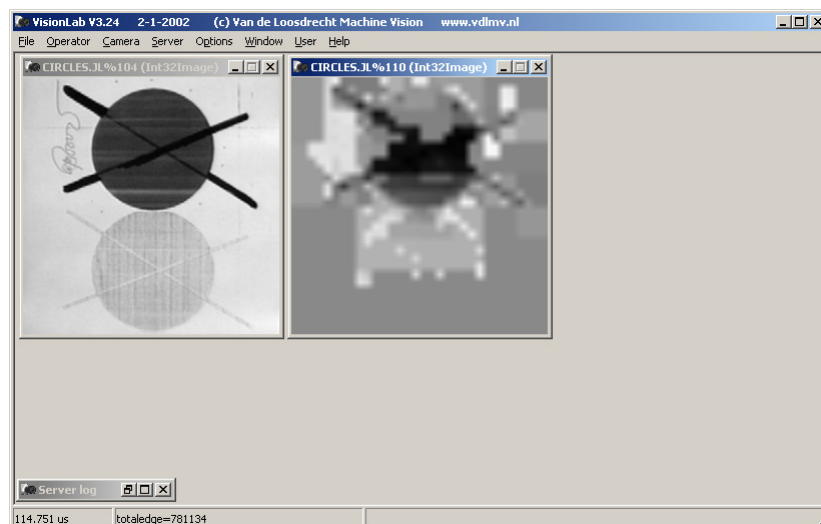
- Open image circles.jl and *convert to Int32Image*
- Zoom circles32.jl 256 256 BilinearPixelInterpolation, size restrictions for RATSLocal, see on-line help
- RATSLocal circles32.jl 50 5 5, creates maskImage
- ThresholdLocal circles32.jl maskImage DarkObject, explain result, explain holes
- ThresholdRATSLocal circles32.jl 50 5 5 DarkObject

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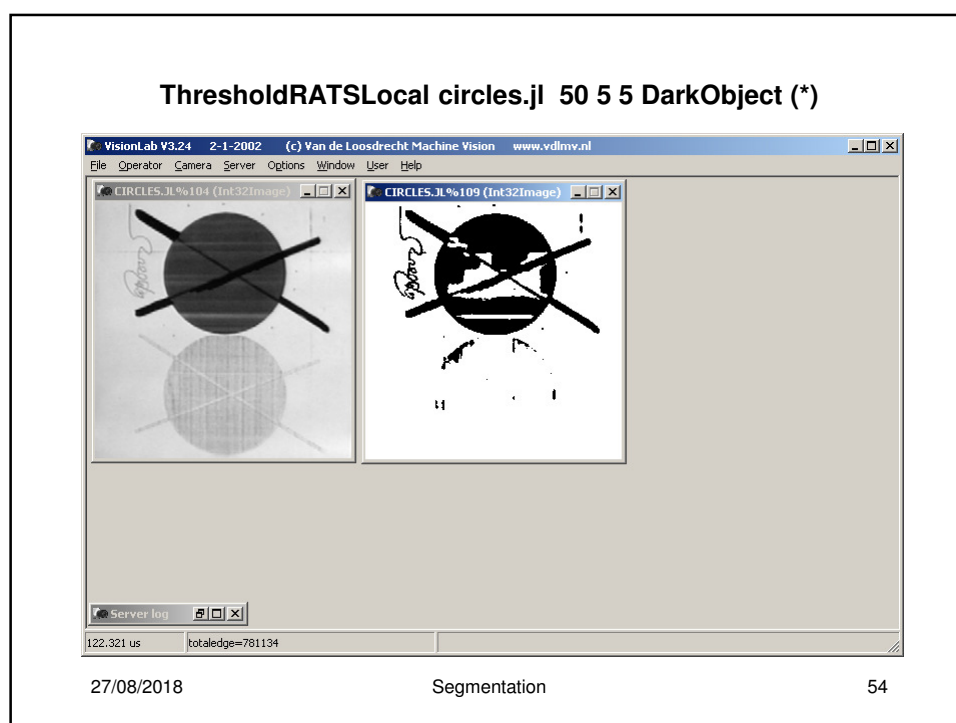
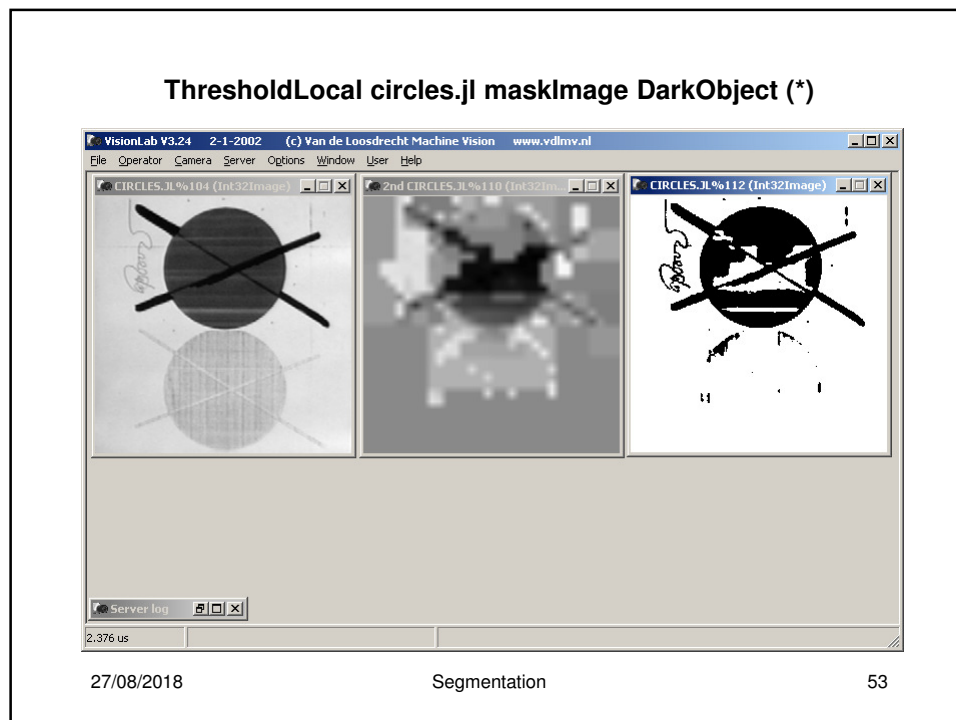
RATSLocal 50 5 5, creates maskImage (*)



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Explanation ThresholdLocal results (*)

NrLevels determines the size of the smallest 'square' in the quadtree. Rule of thumb is that this square should be in the same order of size as the objects which are to be found

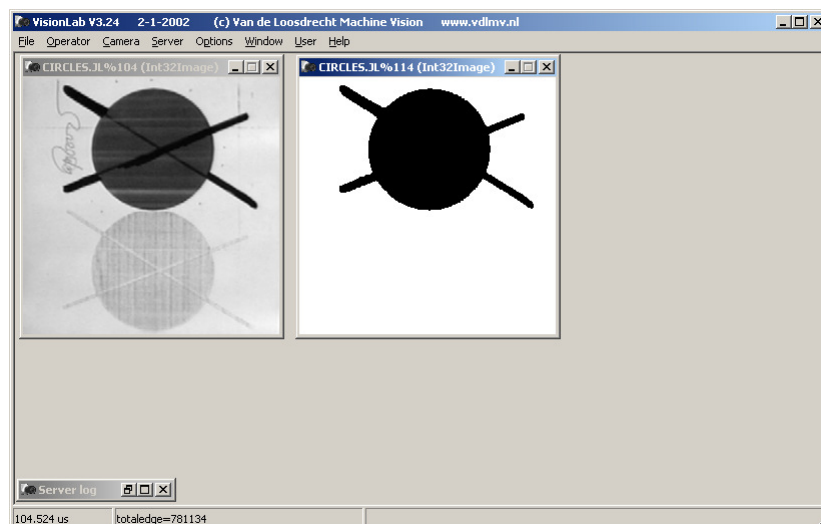
In the previous example the complete dark bal with his legs are found with **NrLevels = 2**

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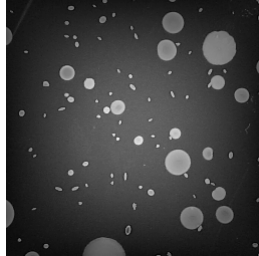
ThresholdLocal with NrLevels = 2 (*)



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Exercise Thresholding (*)

- Use image `shading_c.jl` in the exercise directory
- Use `analyse pixel` to analyse image
- Try to find a correct manual threshold
- Use `ThresholdIsoData` to threshold, what is the result and why?
- Use `ThresholdRATSLocal` and try to find good parameters.

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Feedback exercise Thresholding (*)

- See `shading_c.jls` for answer
- How to find optimal value for parameter `minEdge` ?
 - Sobel `GradientMagnitude`
 - analyse pixels
 - try Threshold 120 10000
 - better result after `FillHoles`, but still problems if incomplete edge of object has been found
 - we will return to this exercise in the lecture about ranking operators

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