

Mathematical Morphology

Christopher Chedeau
Gauthier Lemoine

Overview

▶ Algorithms

- Erosion & Dilation
- Opening & Closing
- Gradient
- Hit & Miss
- Thinning
- Top Hat
- Convolution
- Reconstruction
- Watershed
- Min–Max Tree

▶ Goals

- Segmentation
- Edge detection
- Skeletonization
- Image compression
- Noise reduction
- Feature Detection

Mathematical Morphology

▶ Who

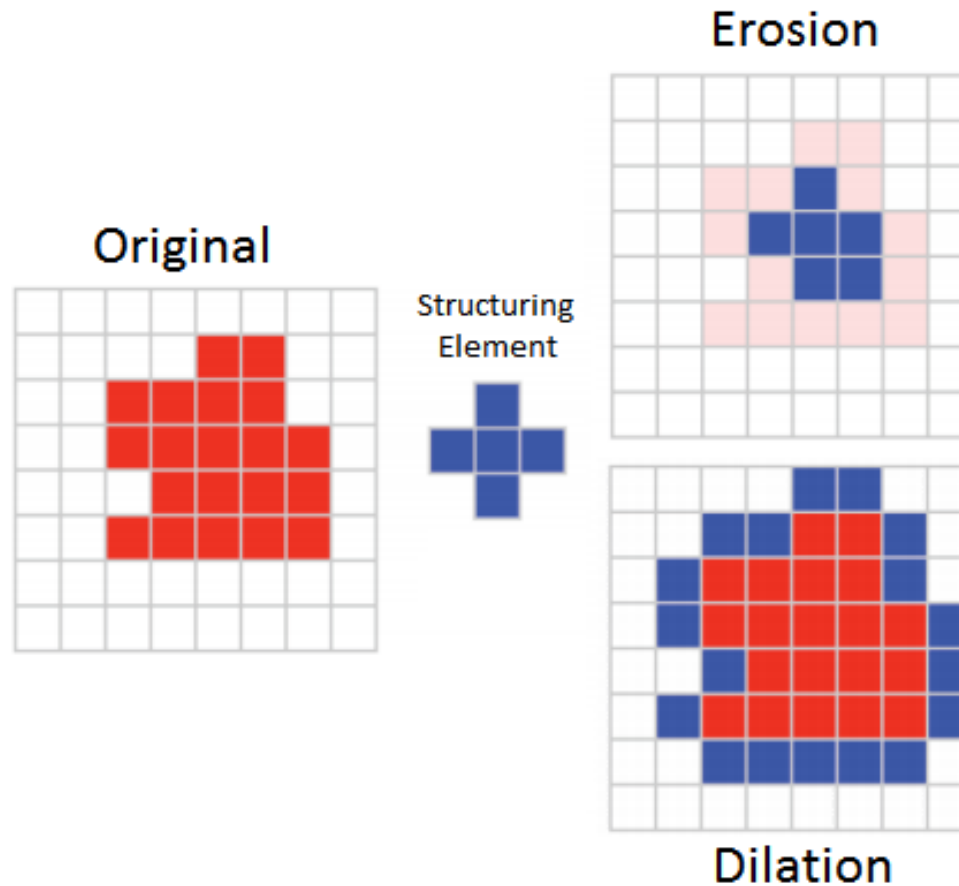
- Ecole des Mines – Paris
- Georges Matheron
- Jean Serra

▶ Theories

- Set Theory (Binary) 70's
- Lattice Theory (Grayscale) 80's
- Topology

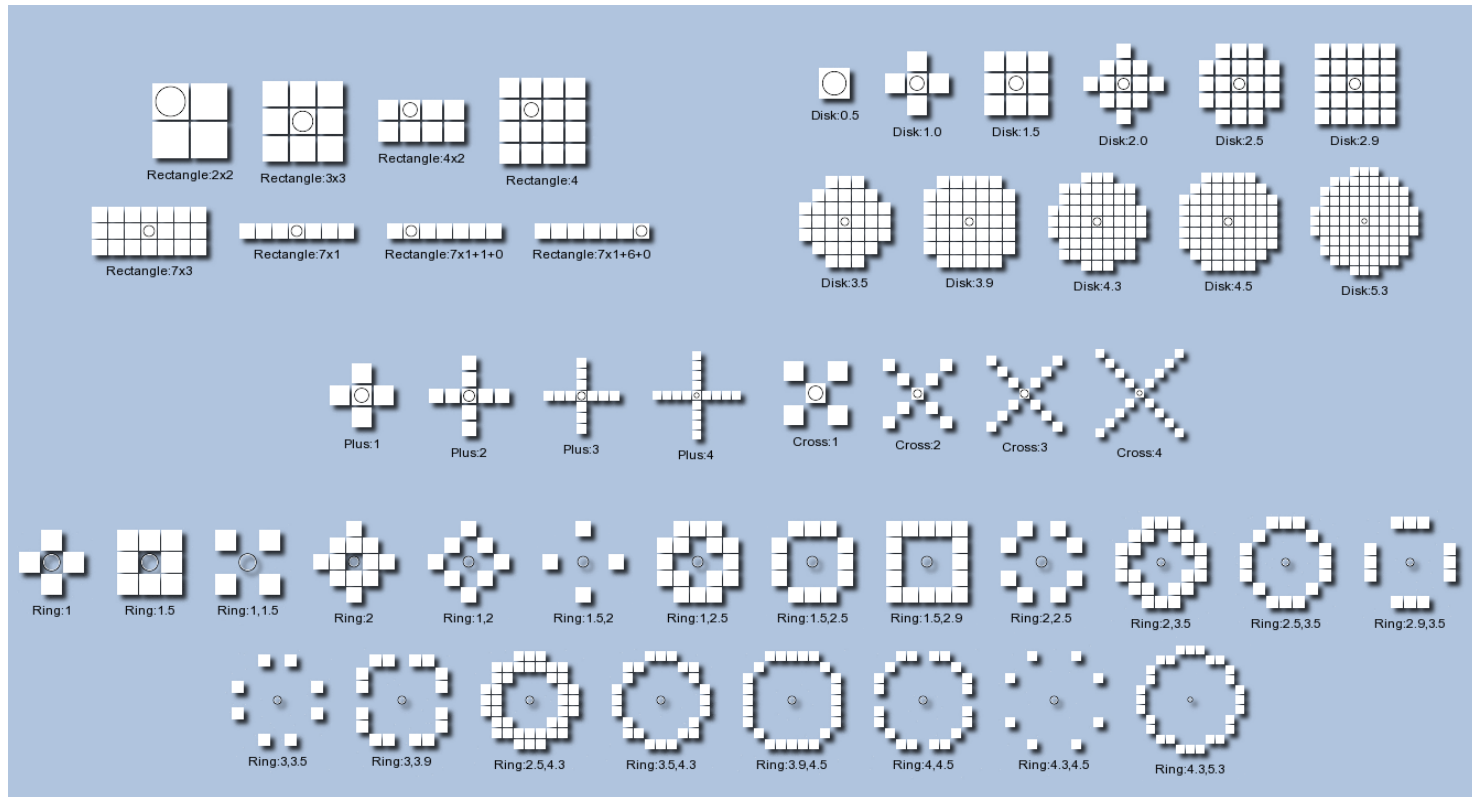
- ▶ http://cmm.ensmp.fr/~serra/pdf/birth_of_mm.pdf

Erosion & Dilation



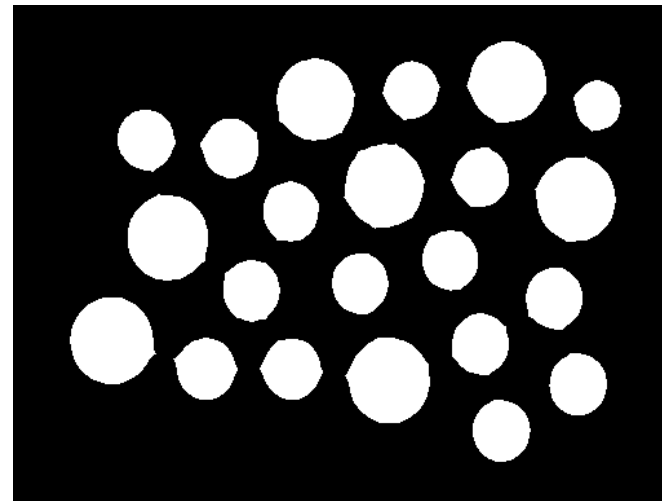
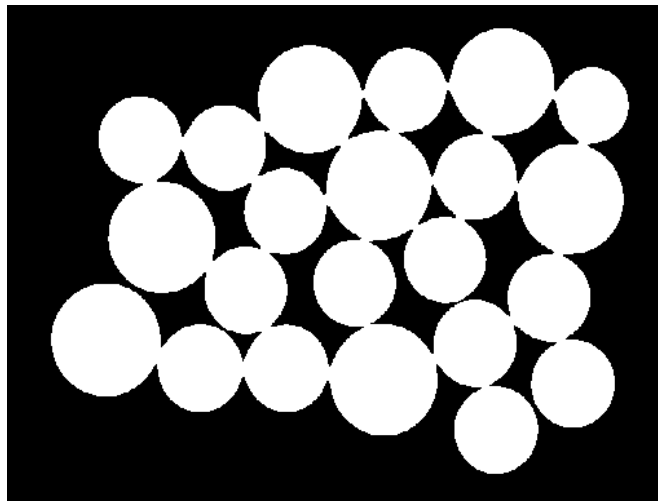
▶ http://www2.ifi.auf.org/personnel/Alain.Boucher/cours/traitement_images/07-Images_binaires.pdf

Structuring Elements



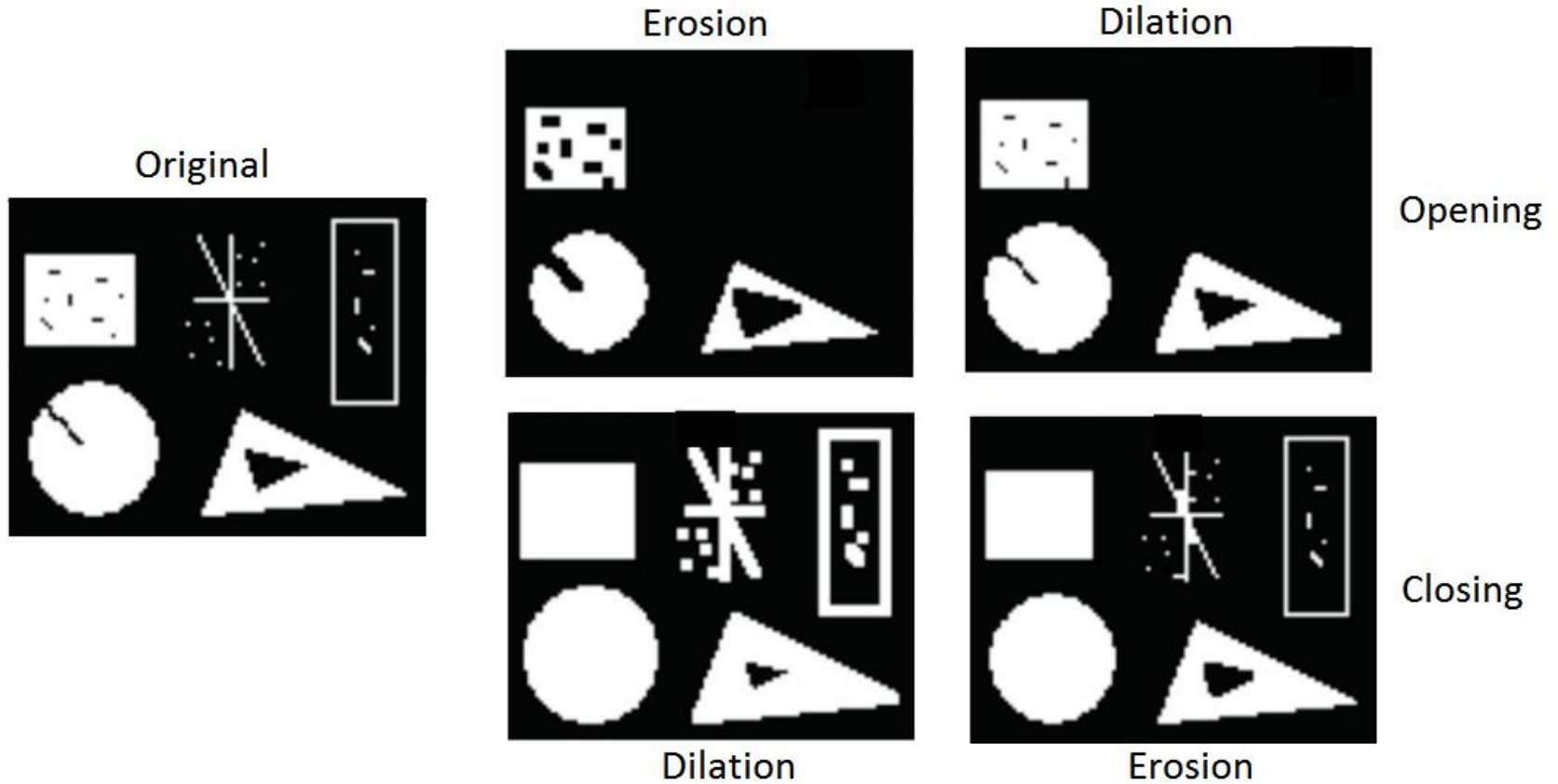
▶ <http://www.imagemagick.org/Usage/morphology/>

Erosion – Disconnect Shapes



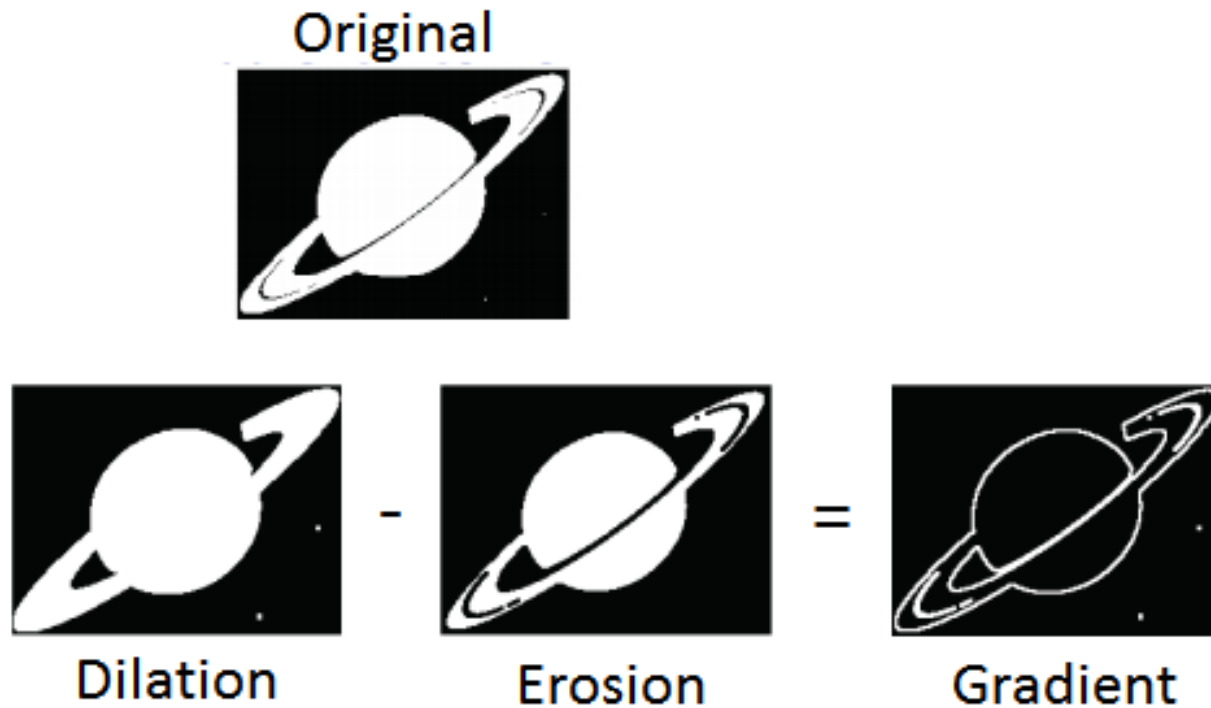
▶ <http://homepages.inf.ed.ac.uk/rbf/HIPR2/erode.htm>

Opening & Closing



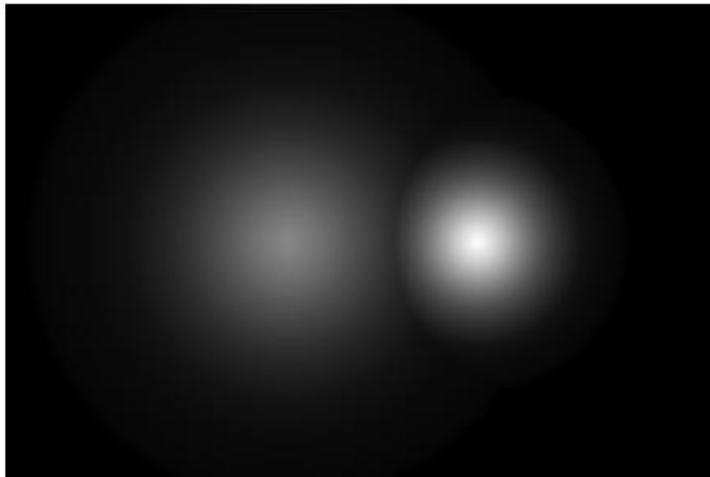
▶ http://www2.ifi.auf.org/personnel/Alain.Boucher/cours/traitement_images/07-Images_binaires.pdf

Gradient

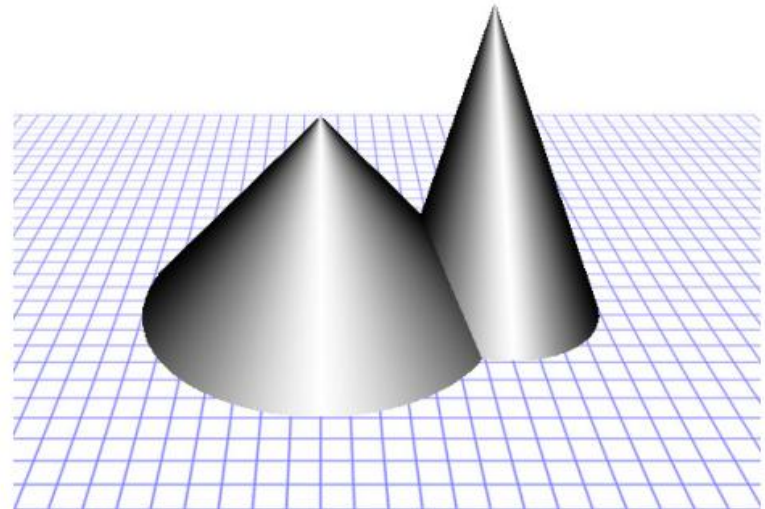


▶ http://www2.ifi.auf.org/personnel/Alain.Boucher/cours/traitement_images/07-Images_binaires.pdf

Grayscale



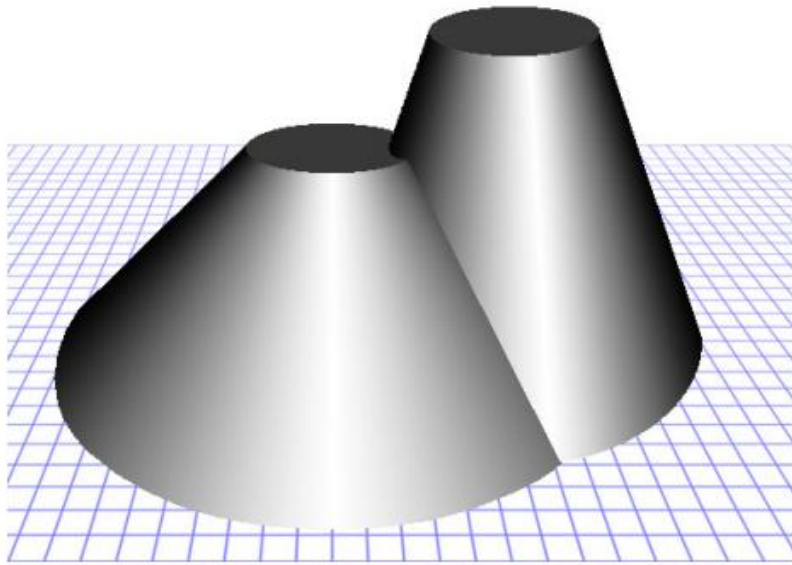
image



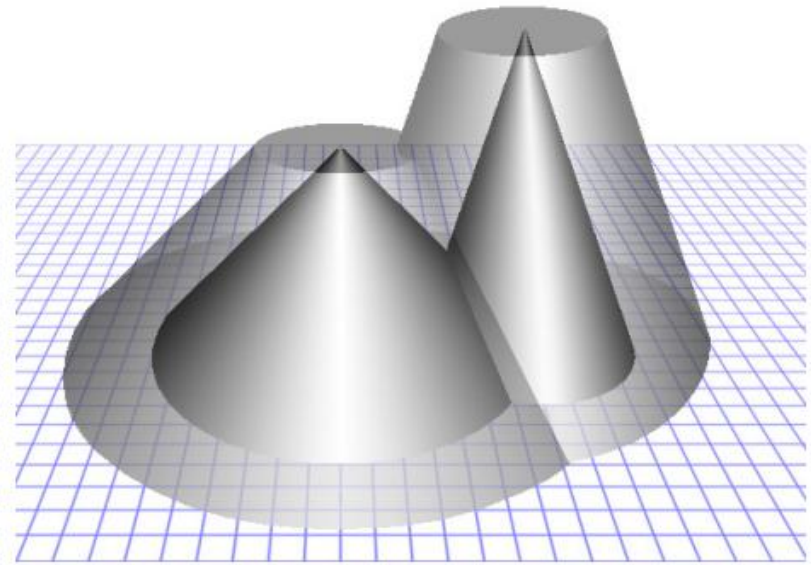
landscape

- ▶ http://ia700307.us.archive.org/7/items/Lectures_on_Image_Processing/EECE253_18_GrayMorphology.pdf

Grayscale – Dilation



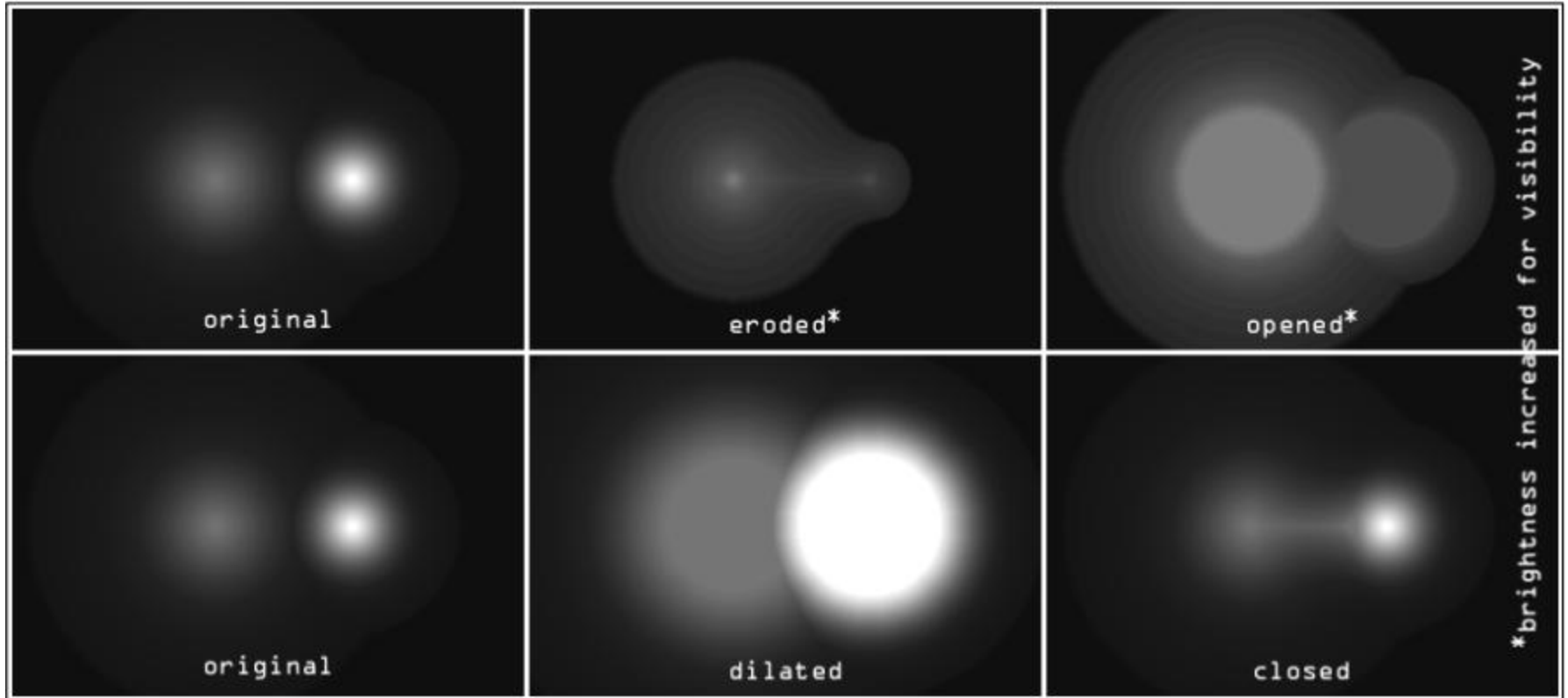
dilation



dilation over original

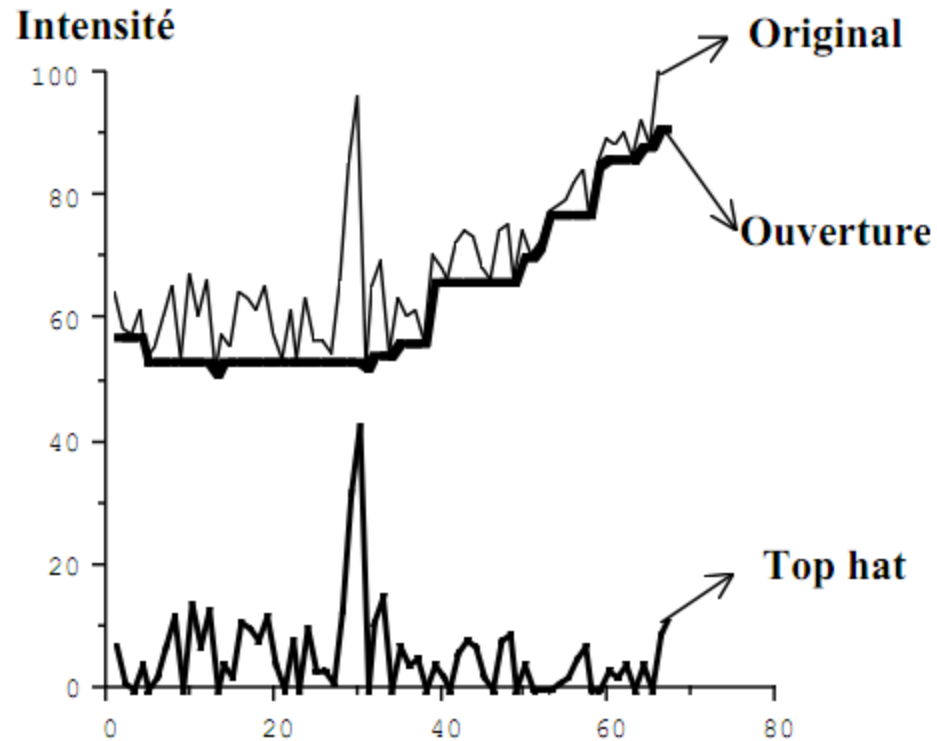
▶ http://ia700307.us.archive.org/7/items/Lectures_on_Image_Processing/EECE253_18_GrayMorphology.pdf

Grayscale – Operations



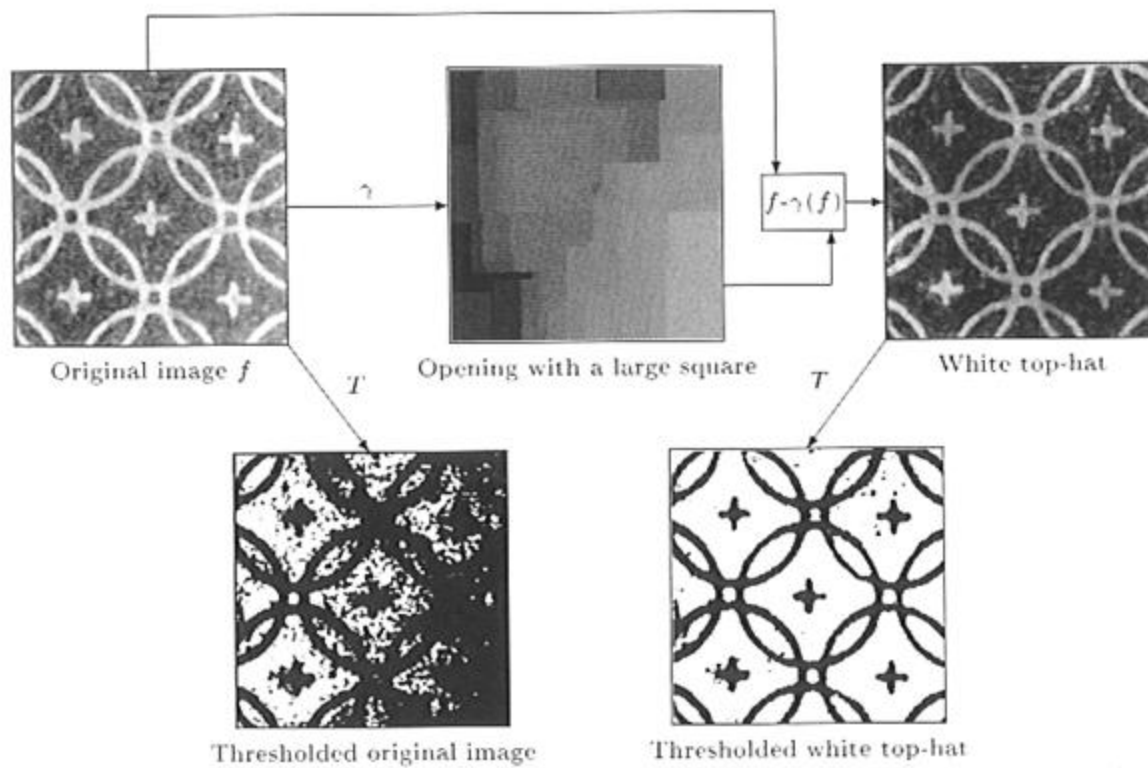
▶ http://ia700307.us.archive.org/7/items/Lectures_on_Image_Processing/EECE253_18_GrayMorphology.pdf

Top Hat



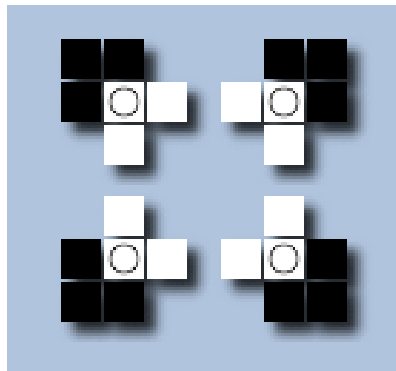
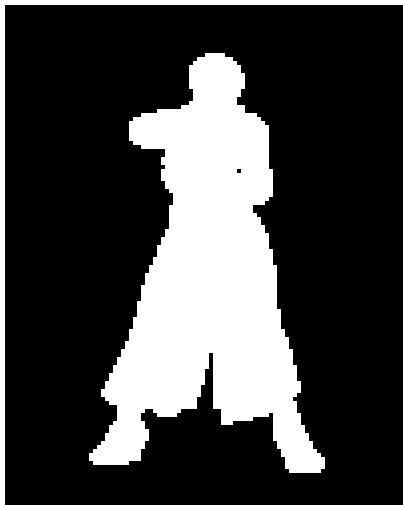
► <http://cmm.ensmp.fr/~serra/cours/pdf/fr/ch3fr.pdf>

Top Hat



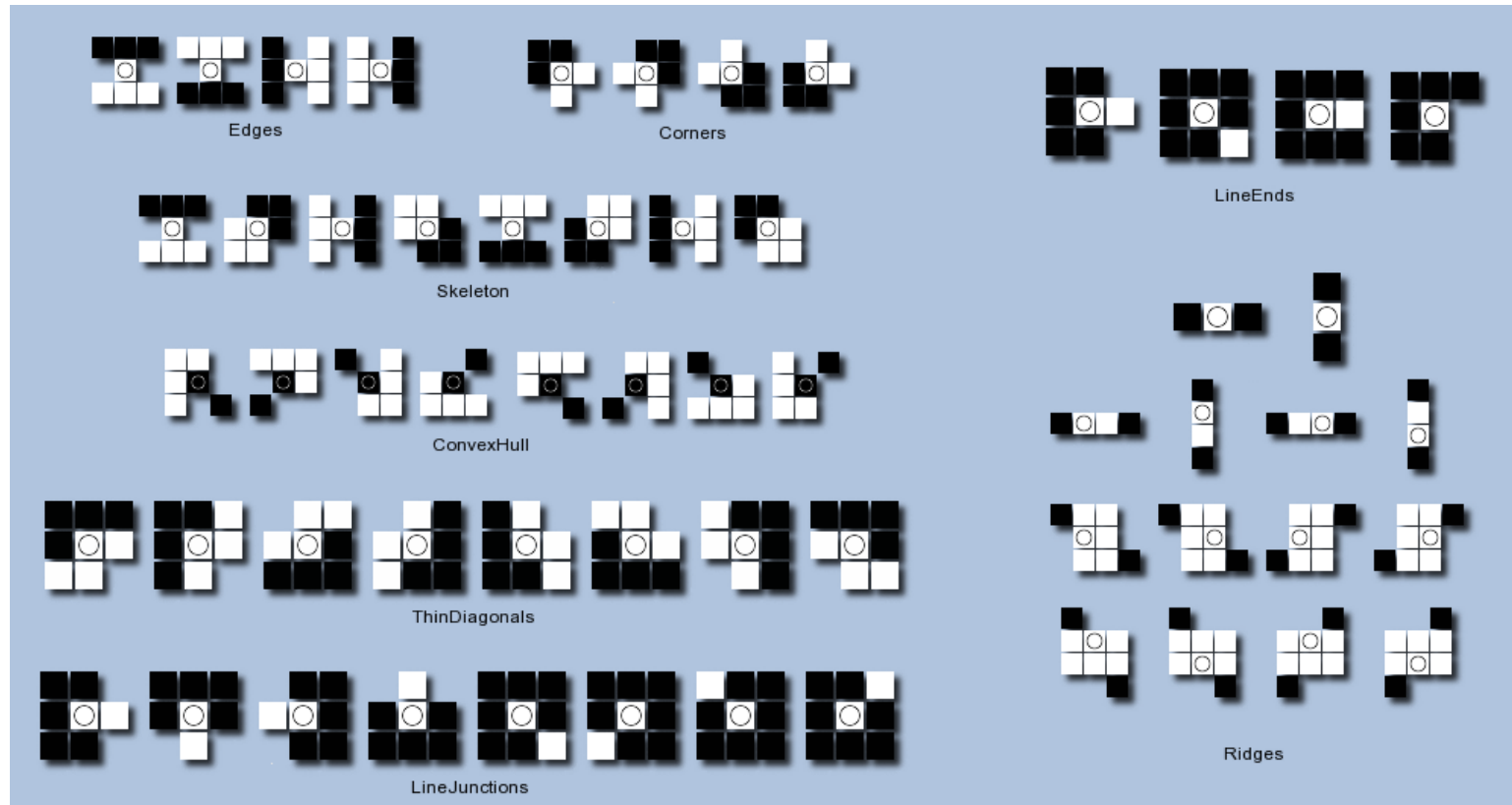
► <http://www.slideworld.org/viewslides.aspx/Introduction-to-Mathematical-Morphology-ppt-172551>

Hit & Miss – Pattern Matching



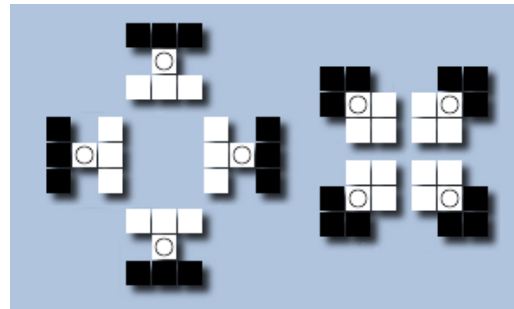
▶ <http://www.imagemagick.org/Usage/morphology/>

Structuring Elements



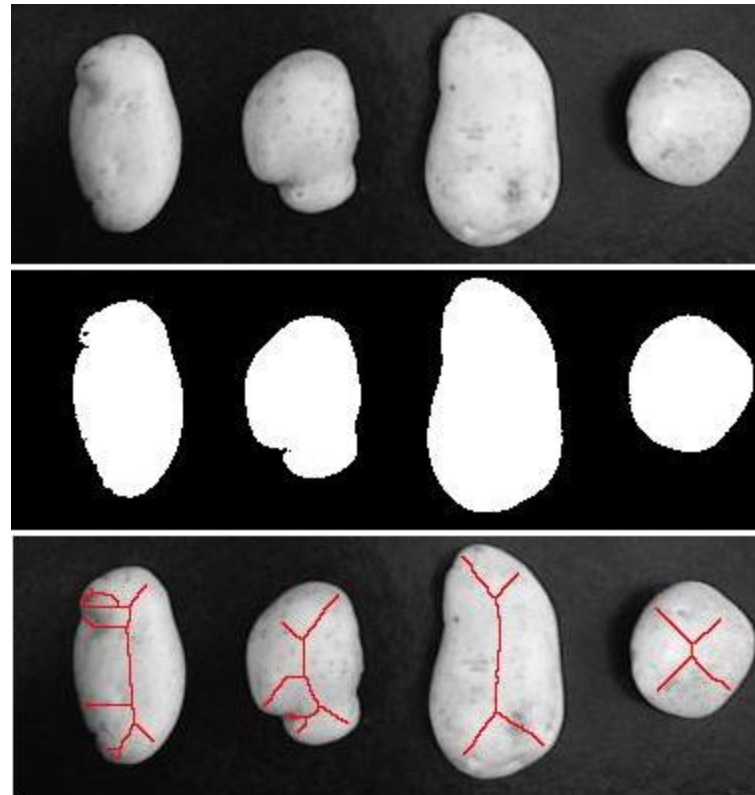
▶ <http://www.imagemagick.org/Usage/morphology/>

Thinning – Skeletonization



▶ <http://www.fmwconcepts.com/imagemagick/morphology/index.php>

Skeletonization – Potatoes

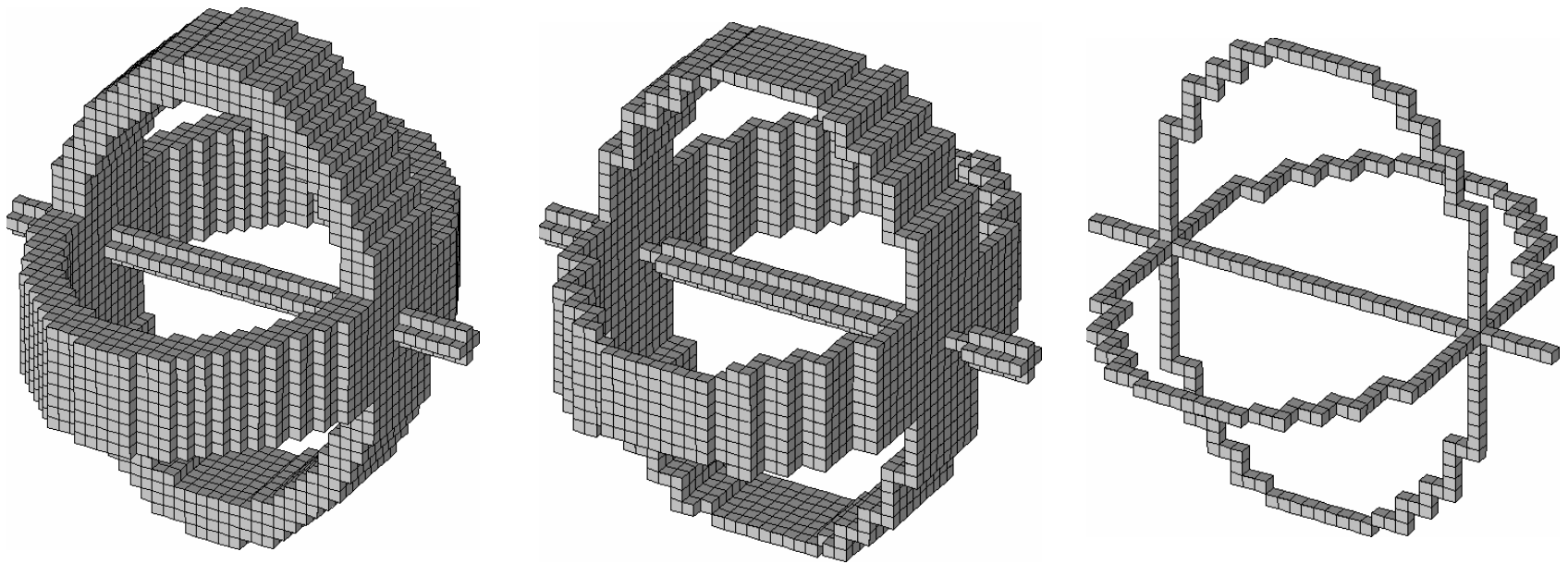


Bad

Good

- ▶ <http://www.mmorph.com/mxmorph/html/mmdemos/mmdpotoes.html>

Skeletonization 3D



▶ http://www.esiee.fr/~coupriem/Sdi_eng/squel.html

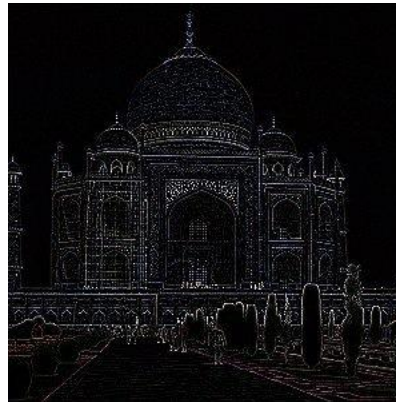
Convolution

Emboss



-2	-1	0	
-1	1	1	
0	1	2	

Edge Detect



0	1	0	
1	-4	1	
0	1	0	

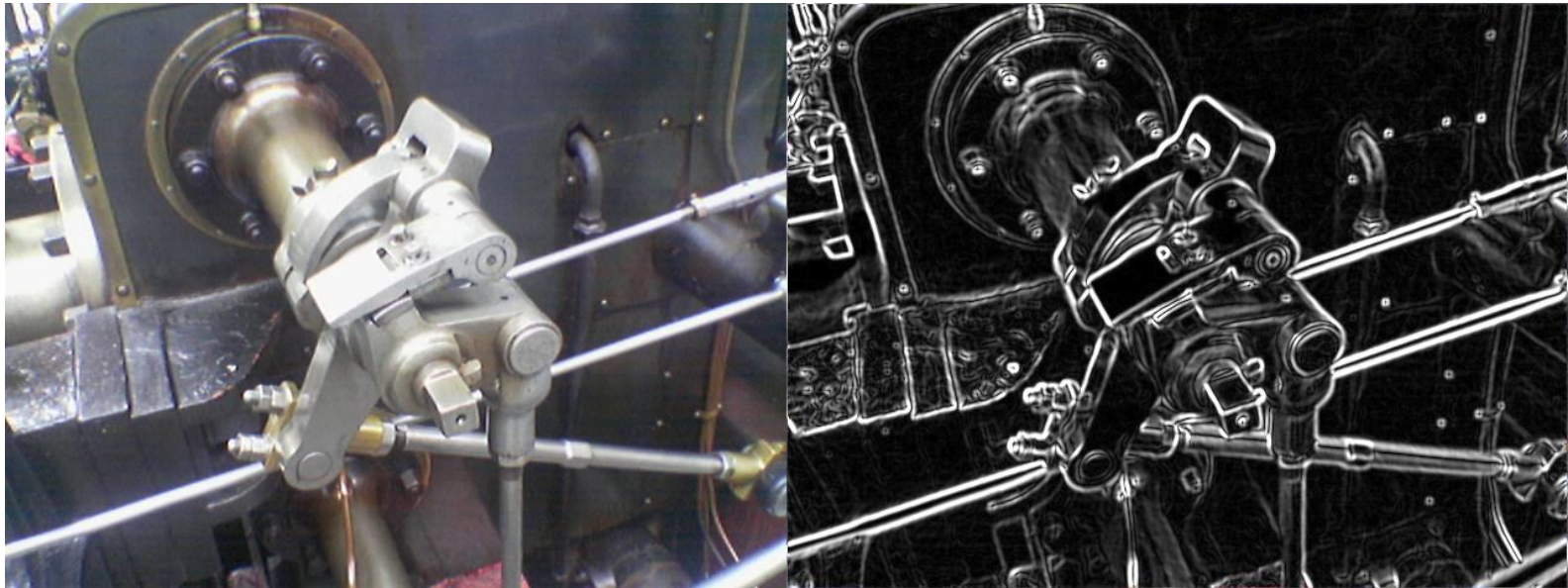
Blur



1	1	1	
1	1	1	
1	1	1	

▶ <http://manual.gimp.org/en/plug-in-convmatrix.html>

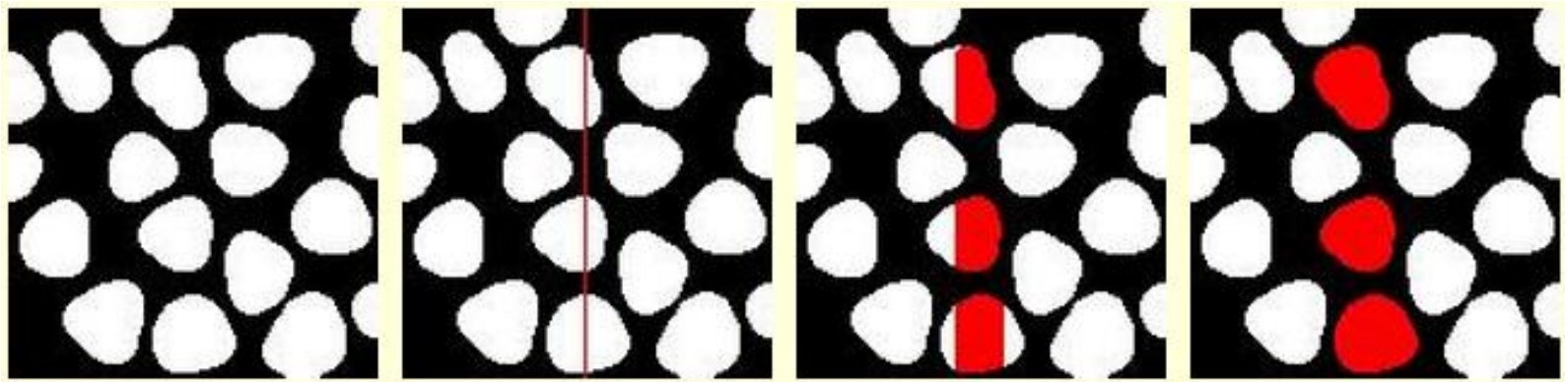
Convolution – Sobel



$$G = \sqrt{G_x^2 + G_y^2} \quad G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * A \quad \text{and} \quad G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A$$

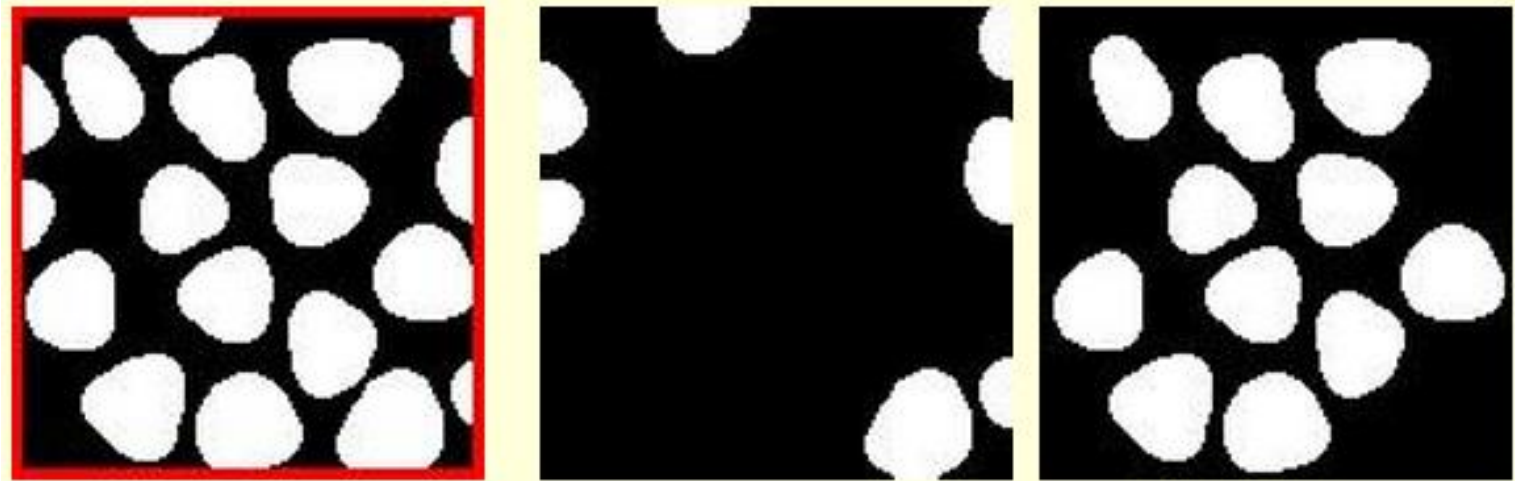
▶ http://en.wikipedia.org/wiki/Sobel_operator

Reconstruction



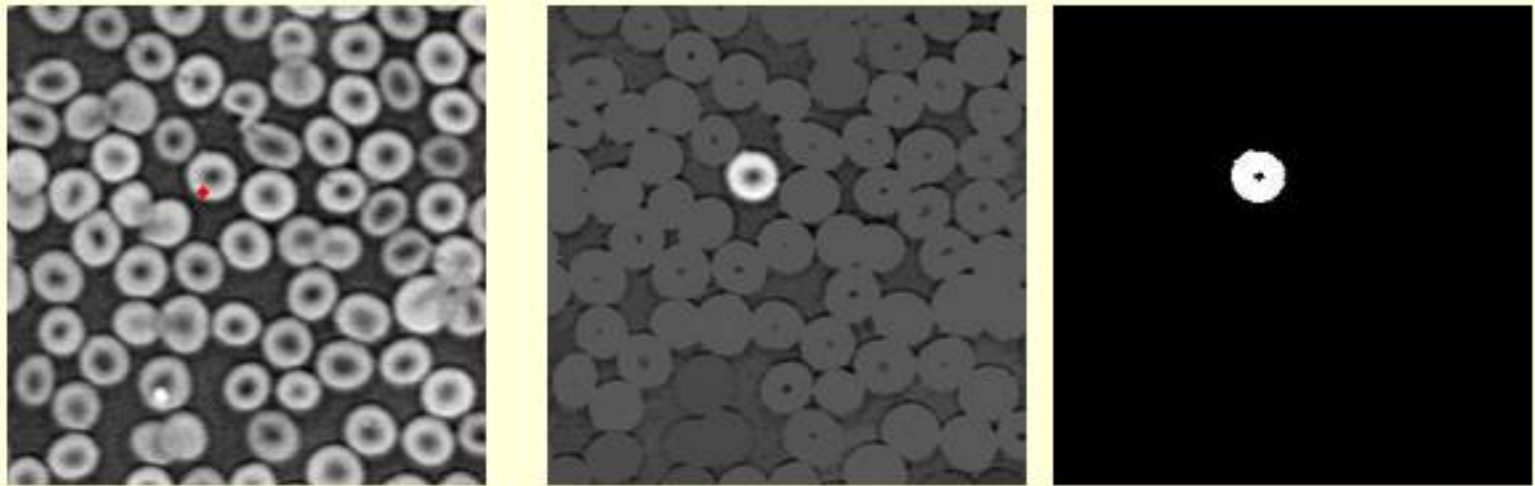
- ▶ <http://www.mmorph.com/mmtutor1.0/html/mmtutor/mm060reconstruction.html>

Reconstruction – Border



- ▶ <http://www.mmorph.com/mmtutor1.0/html/mmtutor/mm060reconstruction.html>

Reconstruction – Grayscale



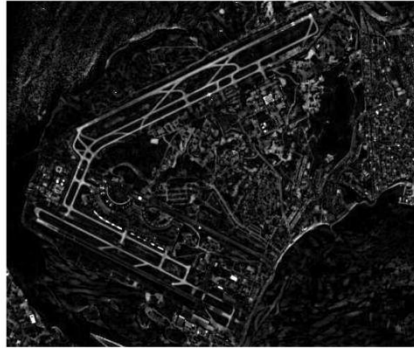
- ▶ <http://www.mmorph.com/mmtutor1.0/html/mmtutor/mm060reconstruction.html>

Airport Runways

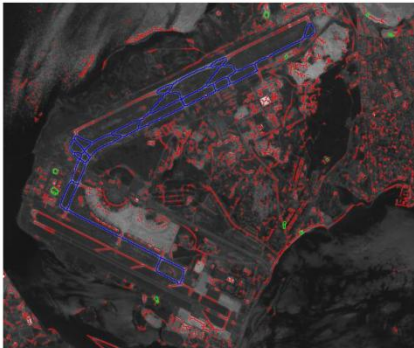
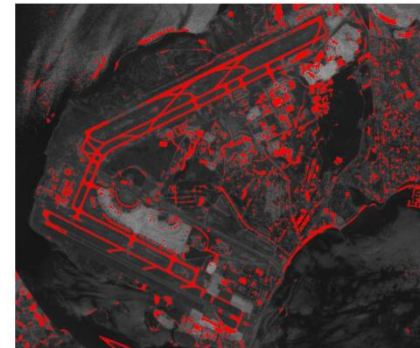
Original



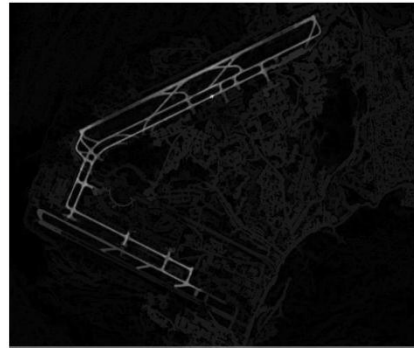
Top Hat



Threshold



Skeletonization
Blue: > 1000px



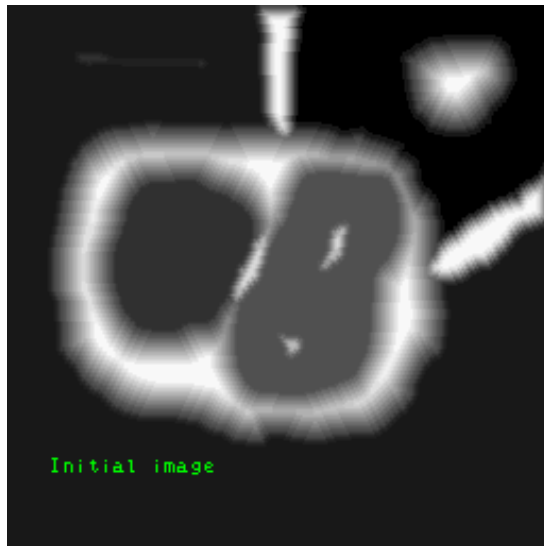
Reconstruction



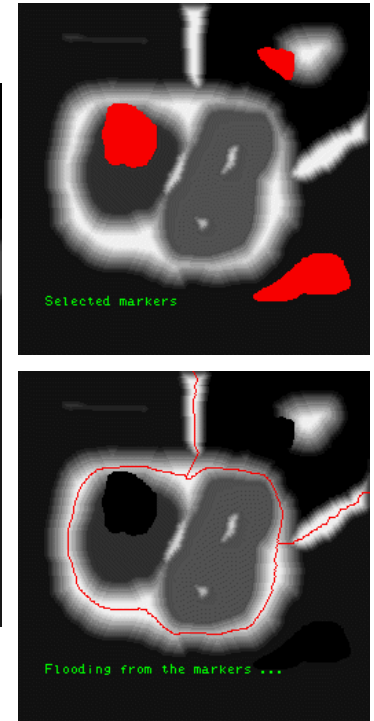
Threshold

▶ <http://www.mmorph.com/mxmorph/html/mmdemos/mmdairport.html>

Watershed

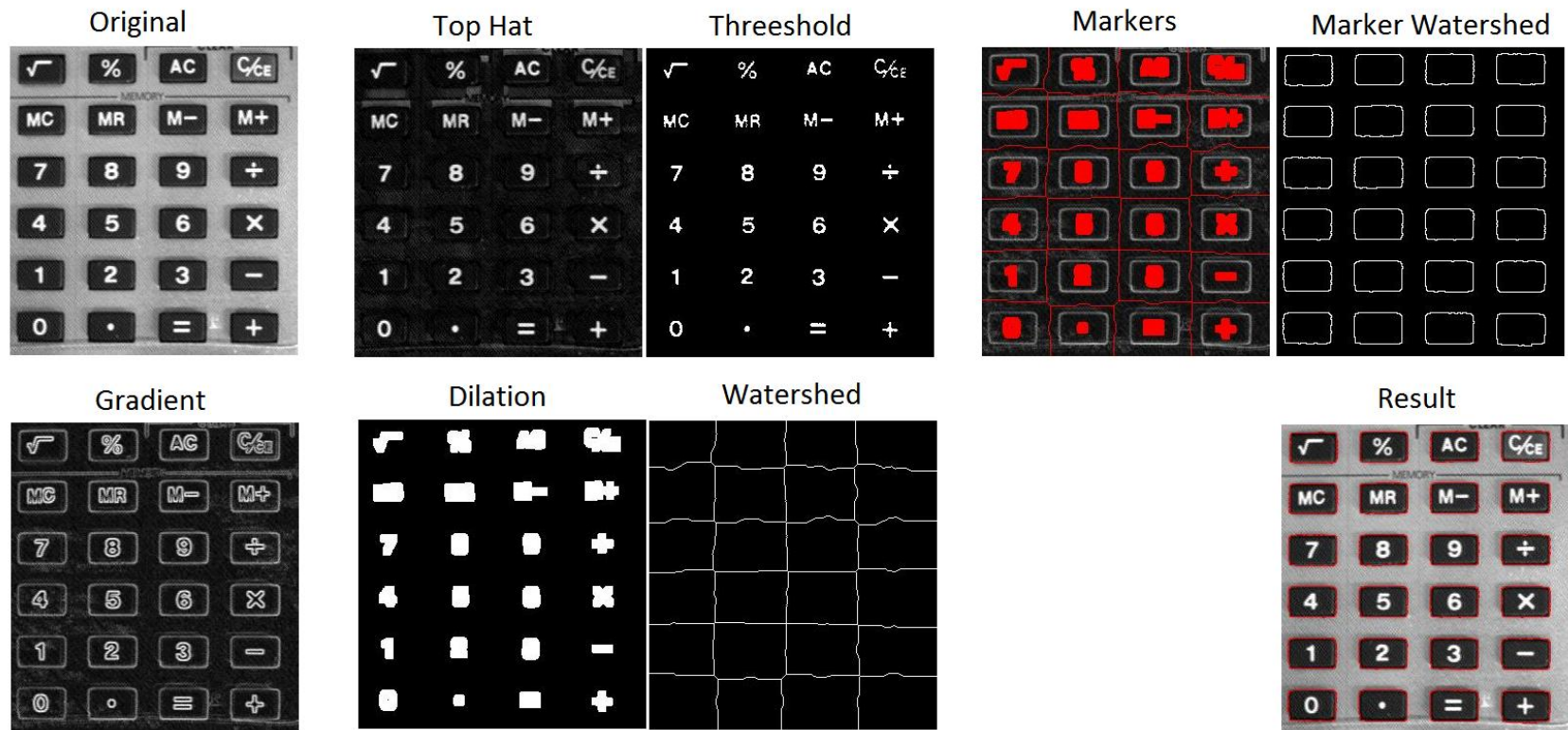


With Markers



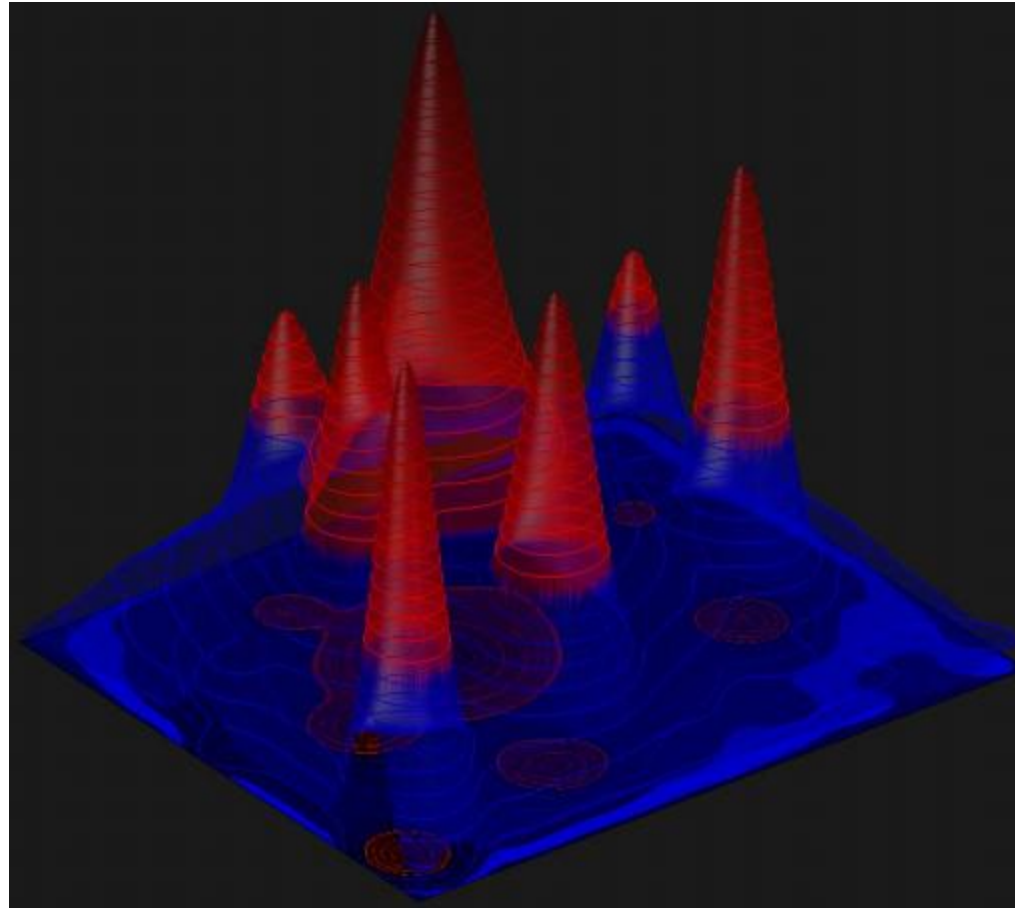
▶ <http://cmm.ensmp.fr/~beucher/wtshed.html>

Watershed – Calculator



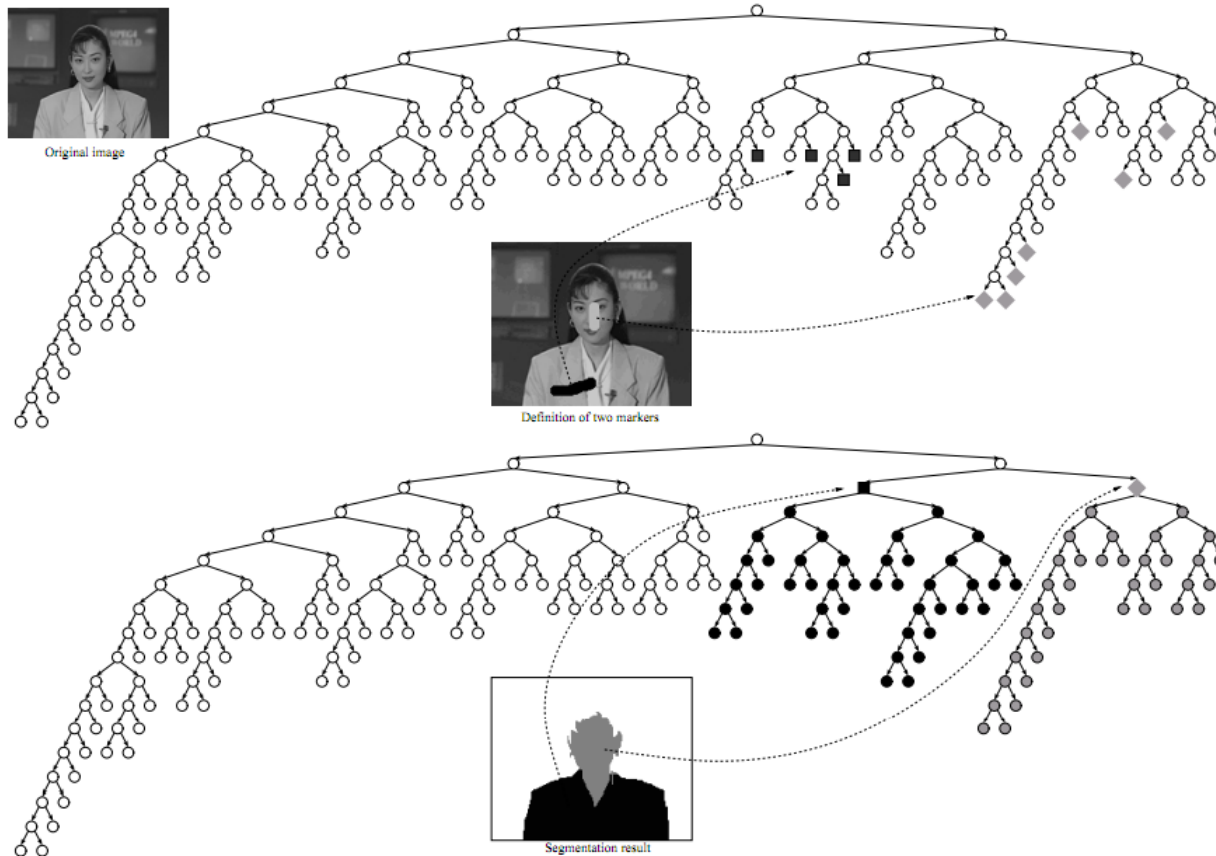
▶ <http://www.mmorph.com/mxmorph/html/mmdemos/mmdcalc.html>

Min-Max Tree



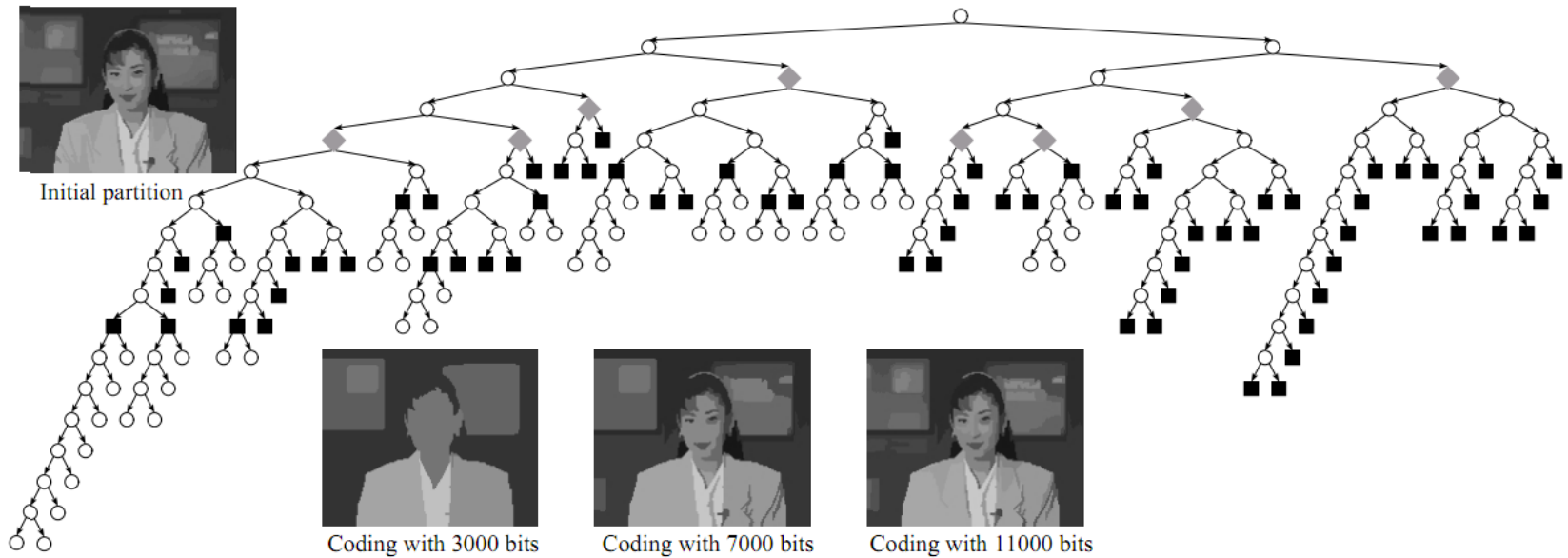
▶ http://www.nanobio.dk/assets/edge_detection.pdf

Min-Max Tree Segmentation



▶ http://gps-tsc.upc.es/imatge/pub/ps/IEEE_IP00_Salembier_Garrido.pdf

Min-Max Tree Compression



▶ http://gps-tsc.upc.es/imatge/pub/ps/IEEE_IP00_Salembier_Garrido.pdf

Questions?