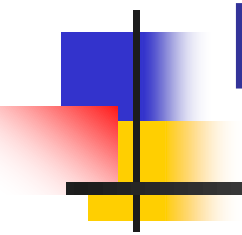
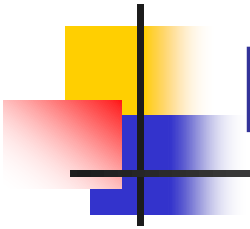


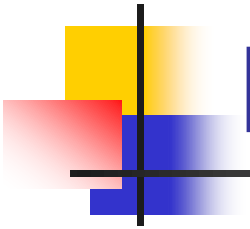
Morphology

Structural processing of images



Mathematical Morphology

- Mathematical morphology is a powerful methodology which was initiated in the late 1960s by G.Matheron and J.Serra at the Fontainebleau School of Mines in France.
- nowadays it offers many theoretic and algorithmic tools inspiring the development of research in the fields of signal processing, image processing, machine vision, and pattern recognition.

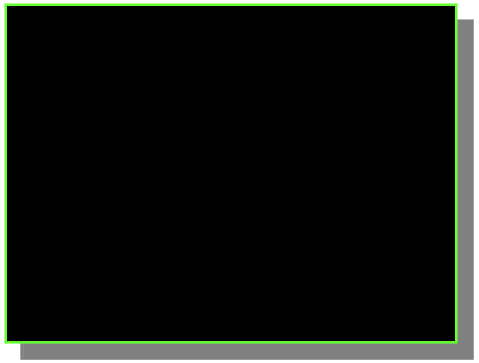


Binary Open and Close

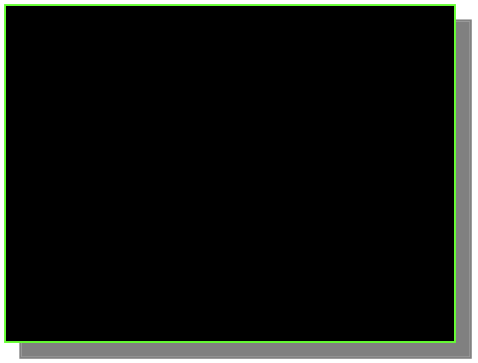
- **Erosion** shrinks an object
- **Dilation** expands it
- Combine these operators:
  - **Open** = erosion then dilation
  - **Close** = dilation then erosion

Morphological Operations

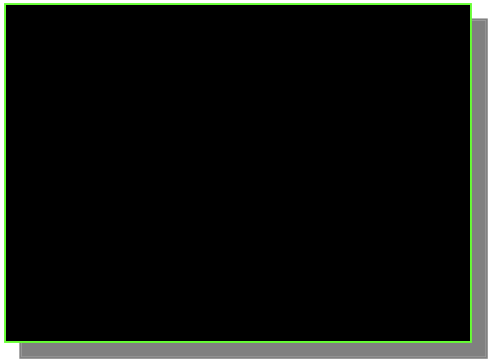
-1. The four most basic operations in mathematical morphology are dilation, erosion, opening and Closing:



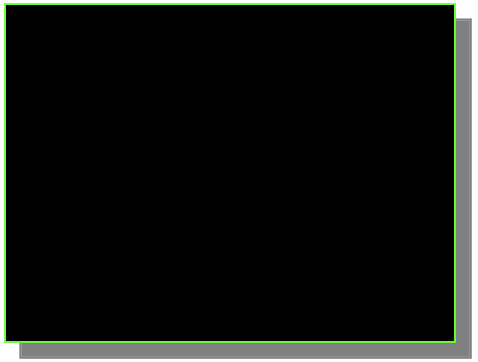
Dilation



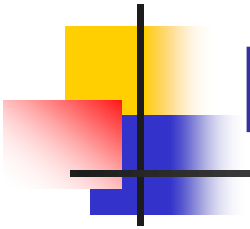
Erosion



Opening=E,D



Closing=D,E

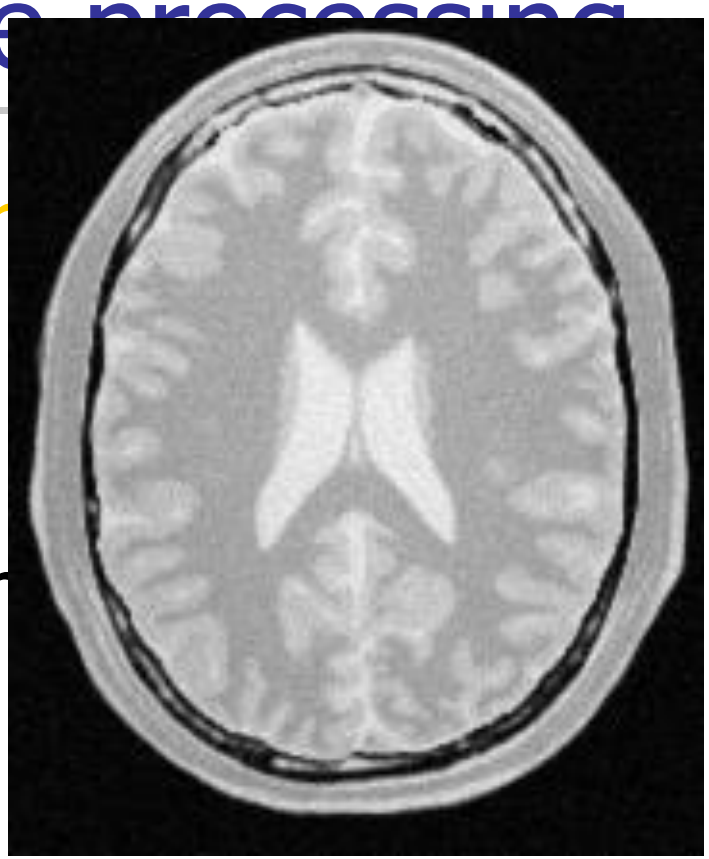


Morphological Transformations

- Set theoretic methods of extracting quantitative descriptions of image components
  - Boundaries
  - Skeletons
  - Convex hull
- Mainly binary, sometimes greylevel
- Two fundamental operations
  - Erode, dilate

Low level image processing

- Image compression
- Noise reduction
- Edge extraction
- Contrast enhancement
- Segmentation
- Thresholding
- Morphology
- Image restoration



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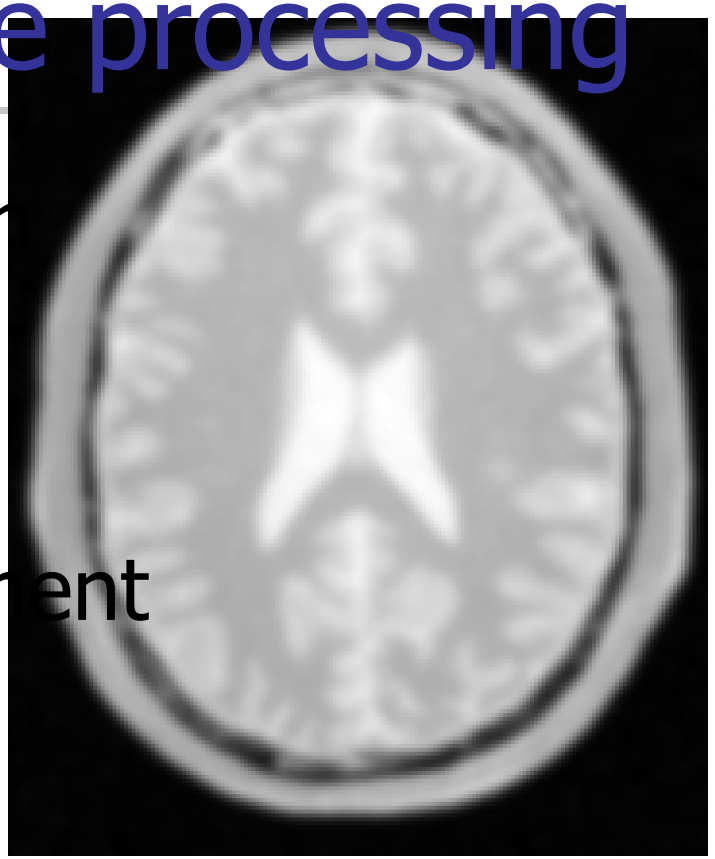

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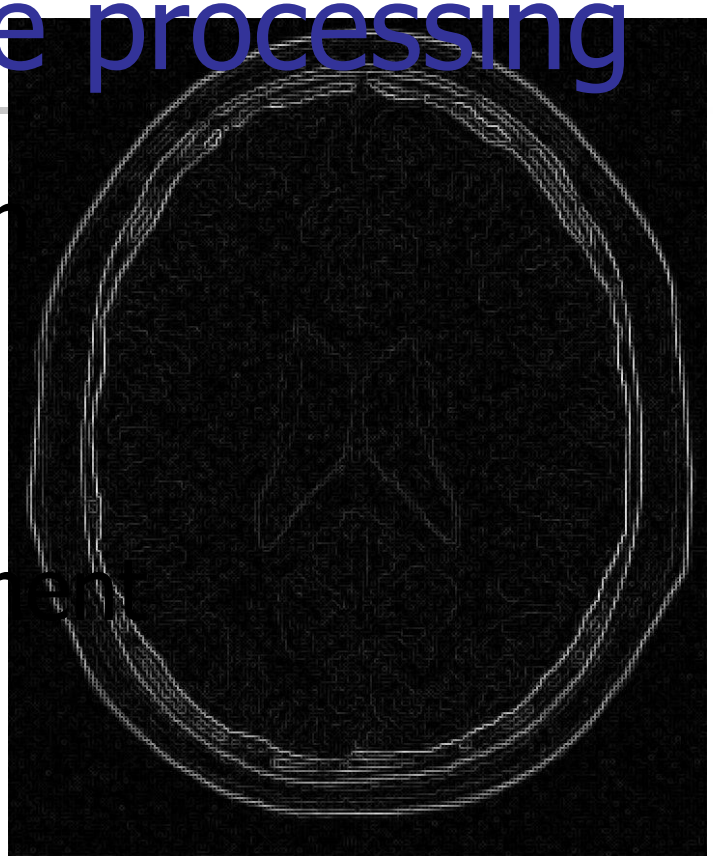

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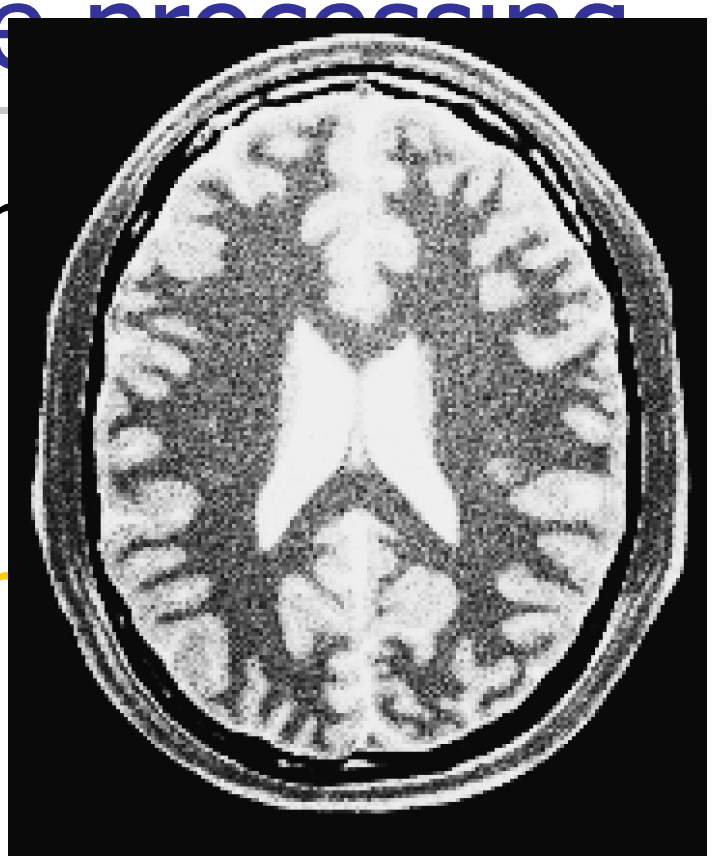

Low level image processing

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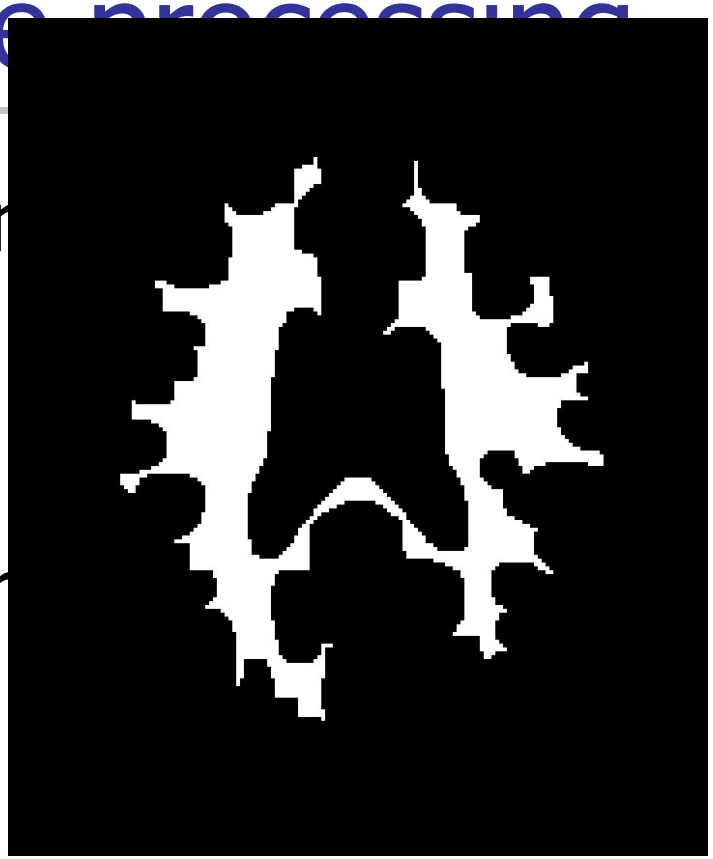

Low level image processing

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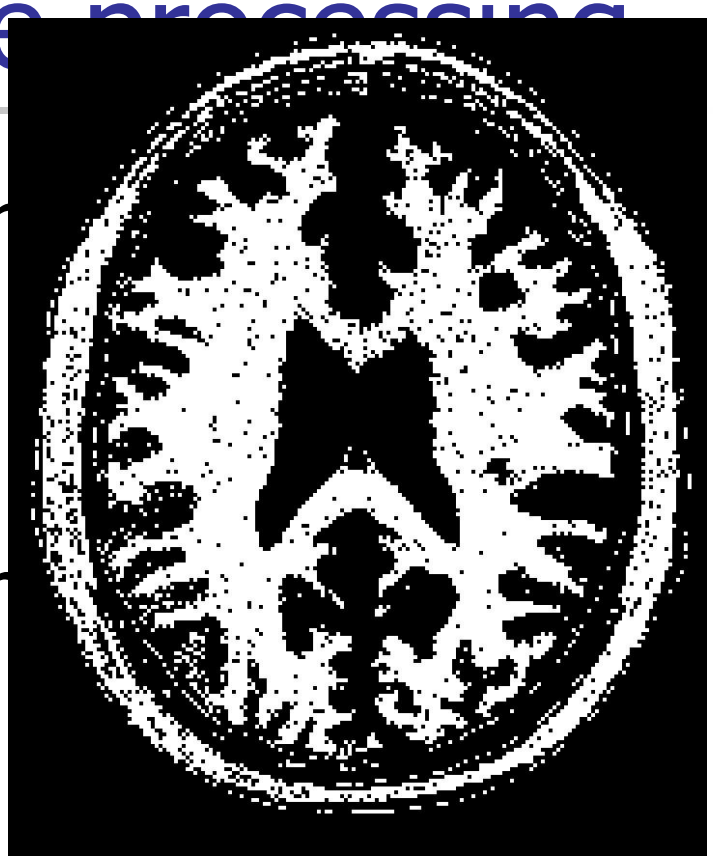

Low level image processing

- Image compression
- Noise reduction
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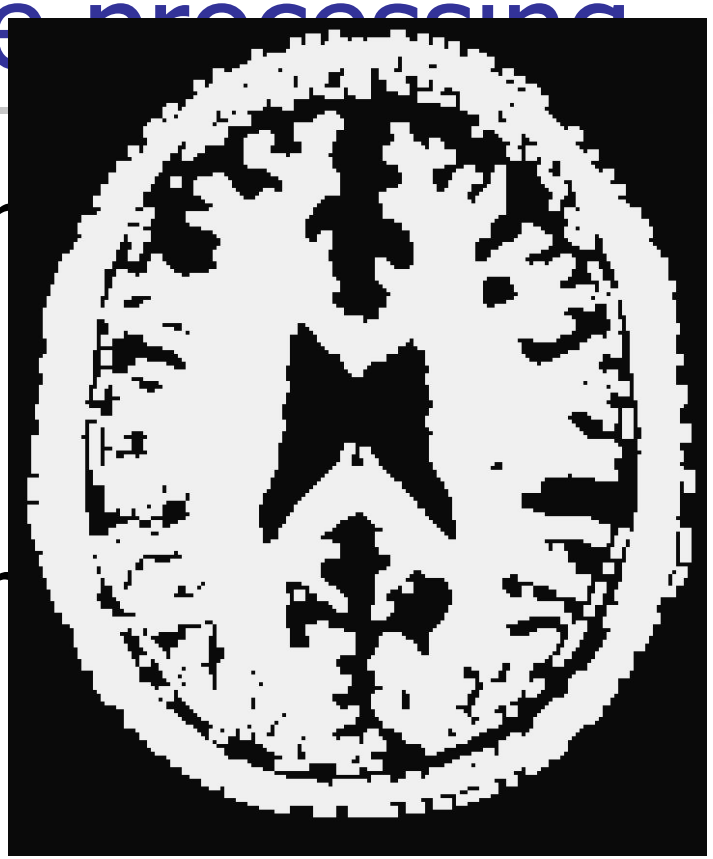
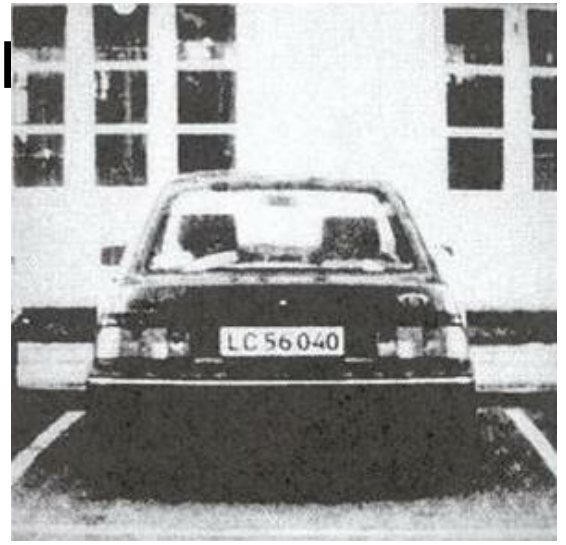
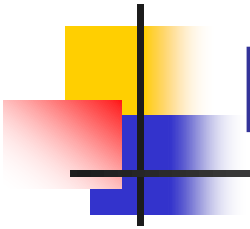
- Image restoration



Low level image

- Image compression
- Noise reduction
- Edge extraction
- Contrast enhancemer
- Segmentation
- Thresholding
- Morphology
- Image restoration





Binary Erode

- Formally

$$A \otimes B = \left\{ x : B_x \subseteq A \right\}$$

- Informally
  - place the structuring element on a pixel of the object
  - remove that pixel if the structuring element overlaps a non-object pixel

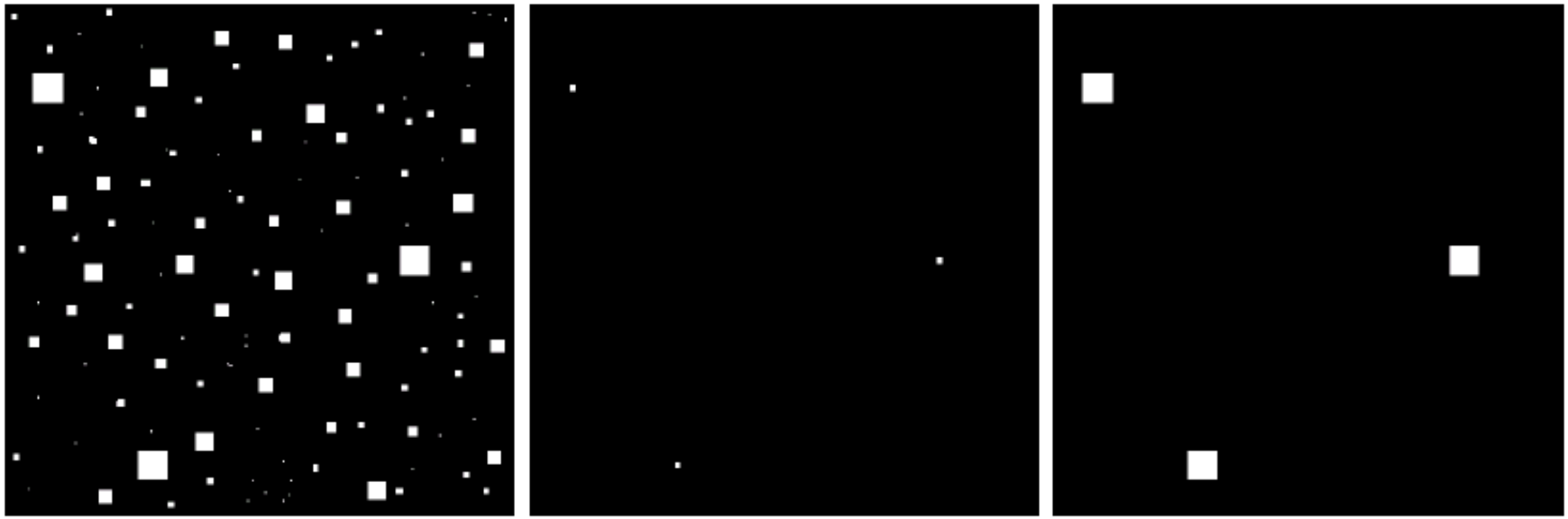
Binary Dilate

- Formally

$$A \oplus B = \left\{ x : \hat{B}_x \cap A \neq \phi \right\}$$

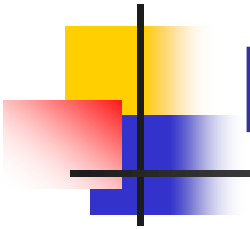
- Informally
  - All pixels covered by structuring element placed at all locations on region

Morphological Image Processing



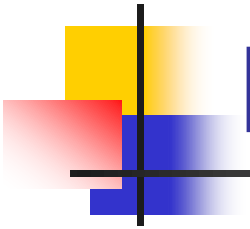
a b c

FIGURE 9.7 (a) Image of squares of size 1, 3, 5, 7, 9, and 15 pixels on the side. (b) Erosion of (a) with a square structuring element of 1's, 13 pixels on the side. (c) Dilation of (b) with the same structuring element.



Binary Open = Erosion then Dilation

- Opening smoothes regions
  - Removes spurs
  - Breaks narrow lines



Binary Close = Dilation then Erosion

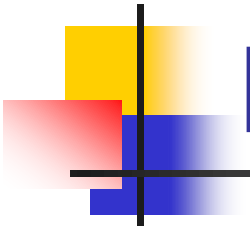
- Closing fills gaps
  - Holes in region
  - Narrow gaps

Example

Binary image

Dilate

Erode



Processing grey scale images

- Same methods can be applied to greyscale images
- Slight redefinition

Greyscale Erode

- Set operation replaced by min operation
  - Output at a point is minimum of image pixel and structuring element pixel

$$D_G(A,B) = \min_{[j,k] \in B} \{a[m-j, n-k], b[j,k]\}$$

Greyscale Dilate

- Set operation replaced by max operation
  - Output is maximum of image and structuring element

$$D_G(A,B) = \max_{[j,k]\in B} \{a[m-j, n-k], b[j,k]\}$$

Examples

Erode

Dilate

Distance

- Applies to binary images
- For each pixel in a region
  - distance = minimum path to outside

0	0	0	0	0
0	1	1	1	0
0	1	1	1	0
0	1	1	1	0
0	0	0	0	0

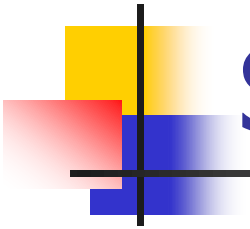
0	0	0	0	0
0	1	1	1	0
0	1	2	1	0
0	1	1	1	0
0	0	0	0	0

Computation

- Use erosion
  - Label removed pixel with iteration number
- Use relationship operator
  - *f(i,j)* are neighbours of *f(x,y)*

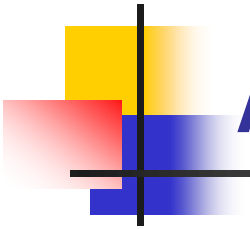
$$f^{0}(x,y) = f(x,y)$$

$$f^{m}(x,y) = f^{0}(x,y) + \min\left(f^{m-1}(i,j)\right)$$



Skeleton

- Reduces regions of a binary image to lines one pixel thick
- Preserves
  - Shape
  - Continuity
- How? Uses?

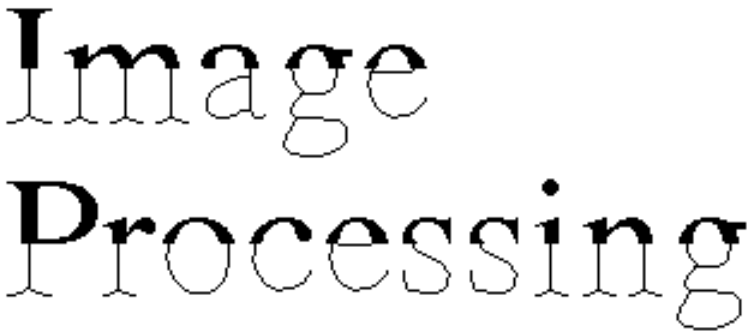


Algorithms

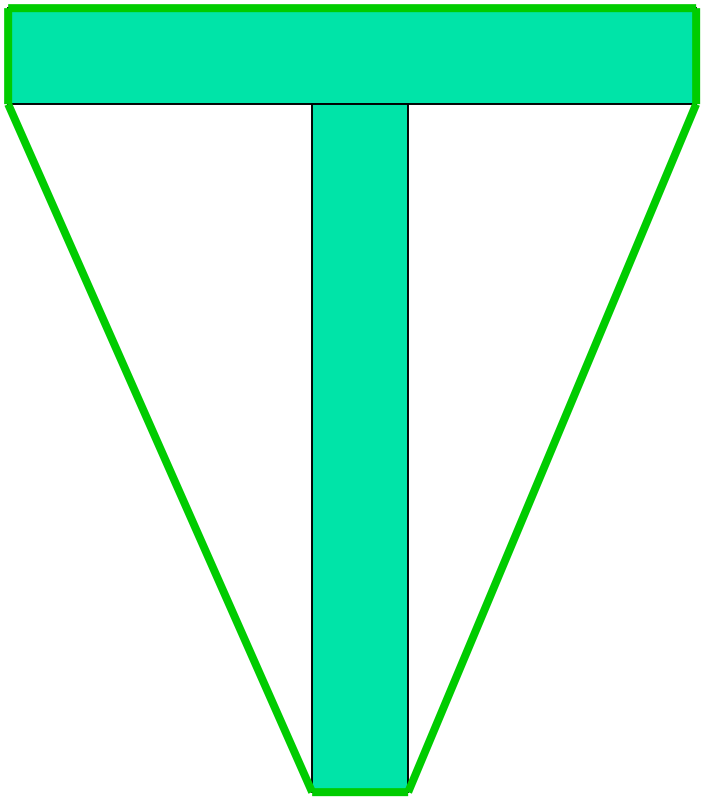
- Thinning
  - Repeatedly thin image
  - Retain end points and connections
- Distance Transform
  - Skeleton lies along discontinuities
  - Sort of local maxima or ridges

Applications

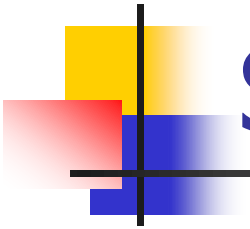
- Shape representation, maintaining topology
- Character recognition



Convex Hull



Convex hull follows outline of object, except for concavities.
Number and shape of regions between convex hull and object are characteristic of object shape.



Summary

- Binary morphology
  - Erode, dilate, open, close
- Greyscale morphology
  - Erode, dilate
- Distance
- Skeleton
- Convex Hull