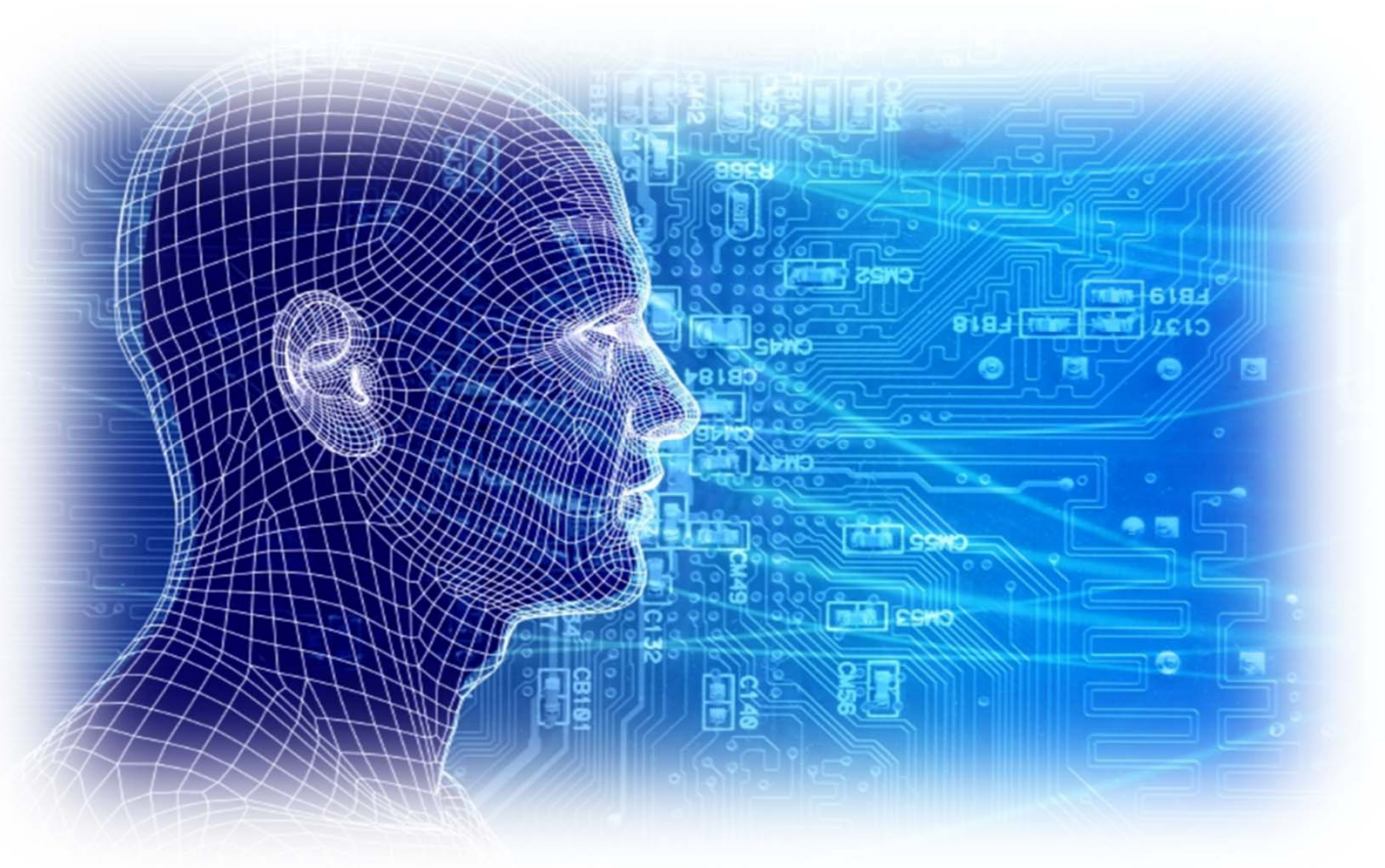
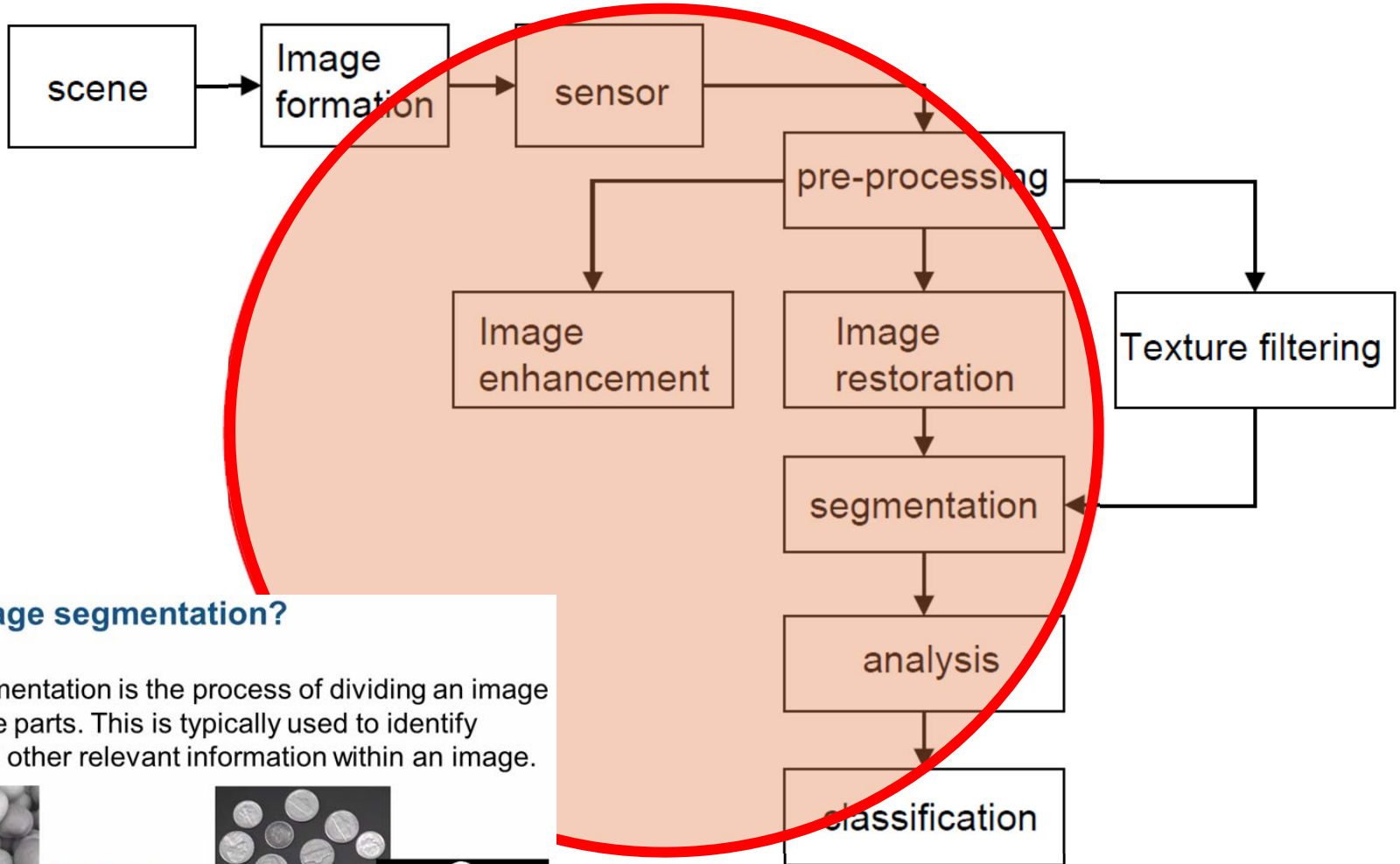
Image Processing & Vision

Week 4



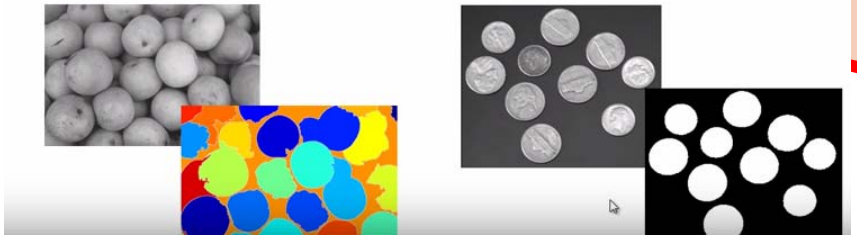
Fontys

Image Analysis Paradigm—where are we?



What is image segmentation?

- Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects and other relevant information within an image.



Content

- Morphological operations
  - **Dilation & Erosion**
  - **Opening & Closing**

- Segmentation
- Edge detection

MORPHOLOGICAL OPERATIONS

Dilation & Erosion

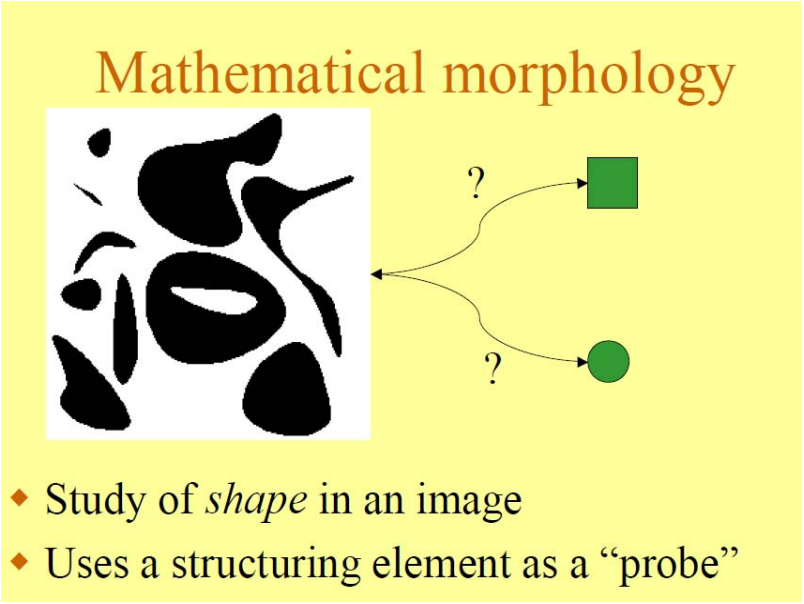
Fontys Brainbitz

What is Morphology in computer vision ?

1. Morphology generally concerned with shape and properties of objects.

2. Used for segmentation and feature extraction.

3. Segmentation = used for cleaning binary objects.



Fontys

Morphological operation

Two basic operations

1. erosion (opening)
2. dilation (closing)

Mathematical Morphology

- Set-theoretic representation for binary shapes

Binary Morphology

- **Libraries of Structuring Elements(SE)**

Application specific SE created by the user!

A structuring element is a shape mask used in the basic morphological operations.

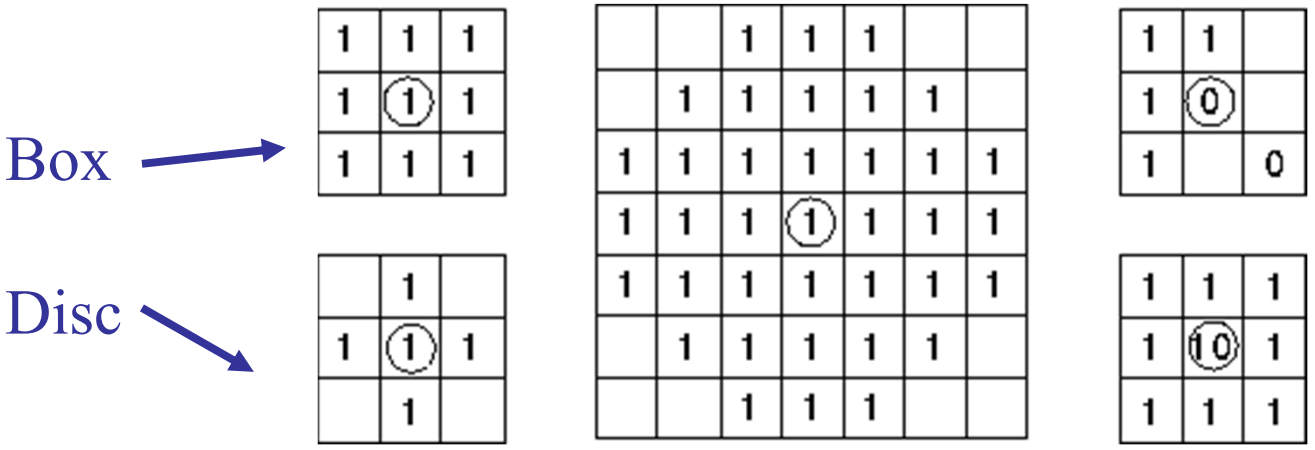
They can be any shape and size that is digitally representable, and each has an origin.

box(length,width)

disk(diameter)

Structuring Element (Kernel)

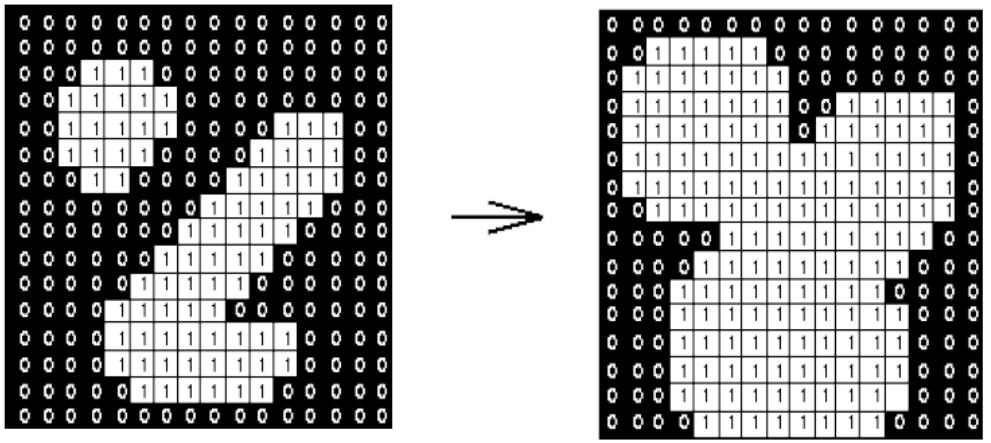
- varying sizes
- element values are 0,1 and none(!)
- Structural Elements have an origin
- For thinning, other values are possible
- Empty spots in the Structuring Elements are *don't care*'s!



Examples of stucturing elements

DILATION ←→ EROSION

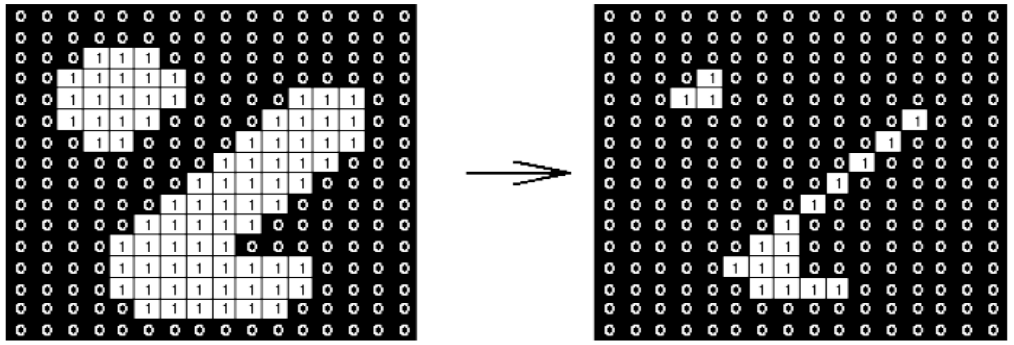
- Dilation (OR)
  - expands binary regions



Effect of dilation using a 3×3 square structuring element

- Erosion (AND)
  - shrinks

Applications of erosion :
Eliminating unwanted detail



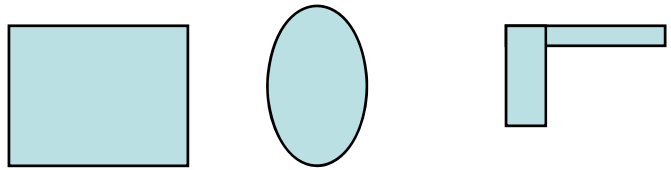
Effect of erosion using a 3×3 square structuring element

Fontys

DILATION

- Dilation (OR)
  - expands binary regions

- Properties:
  - It grows or thicken objects
  - Thickening is controlled by **Structuring Element (SE)**



  - Structuring element is a matrix of 1's and 0's

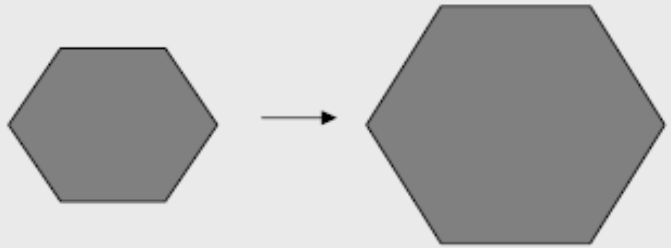
Fontys

DILATION : Main Applications

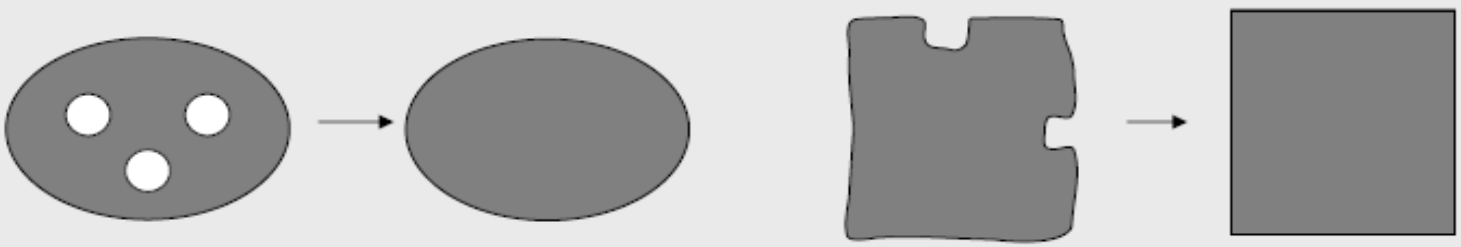
Dilation expands the connected sets of 1s of a binary image.

It can be used for

1. expanding shapes:

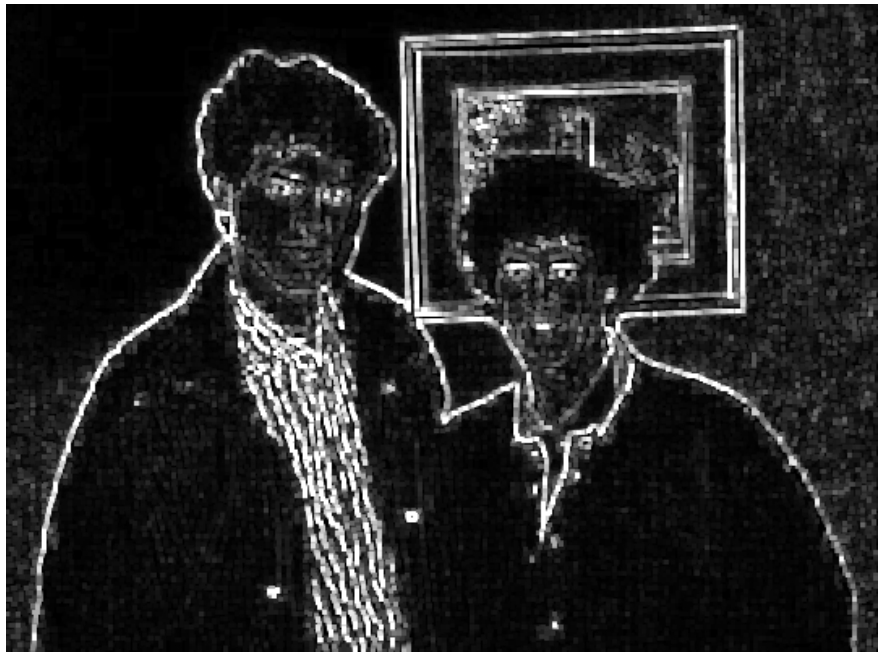


2. filling holes, gaps and gulfs:



Fontys

DILATION EXAMPLE



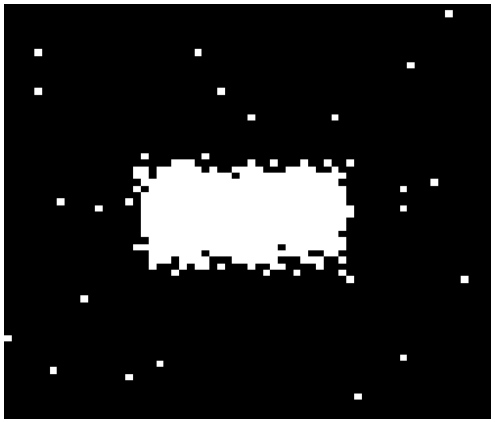
Fontys

EROSION

- Erosion (AND)
  - Shrinks
- Properties:
  - Erosion removes **spiky edges**
    - objects are light (white in binary)
    - decreases geometrical area of object
    - sets contour pixels of object to background value

EROSION: Main Applications

1. Remove isolated noisy pixels.
2. Smooth object boundary.
3. Remove the outer layer of object pixels, so object becomes slightly smaller.



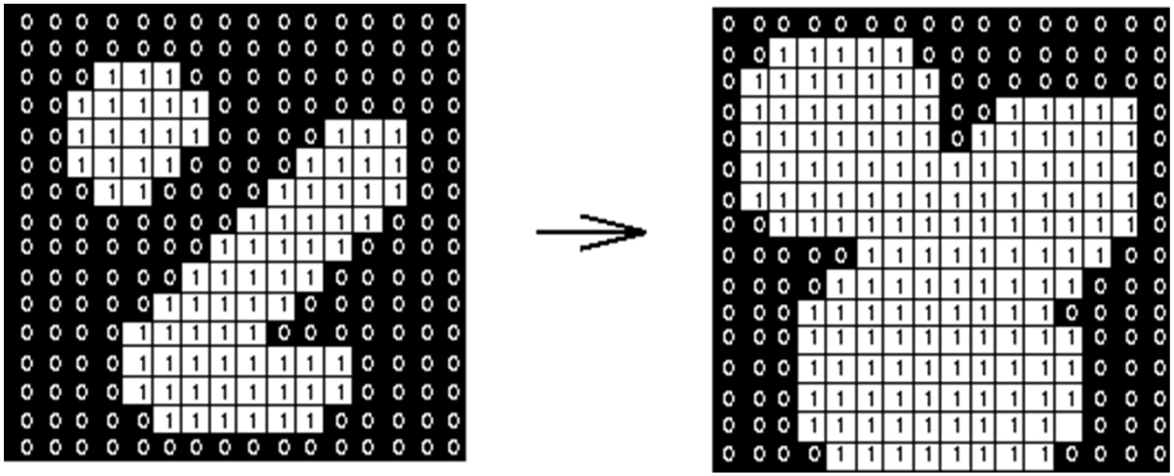
Fontys

DEMO

- https://www.youtube.com/watch?v=8Ta-OcdJMMo

Example: Dilation

- **Dilation** is an important morphological operation



- Applied **Structuring Element**:

1	1	1
1	1	1
1	1	1

Set of coordinate points =

{ (-1, -1), (0, -1), (1, -1),
(-1, 0), (0, 0), (1, 0),
(-1, 1), (0, 1), (1, 1) }

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	1								

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	1	0							

Input image

1	0	0	0	1	1	1	0	1	1

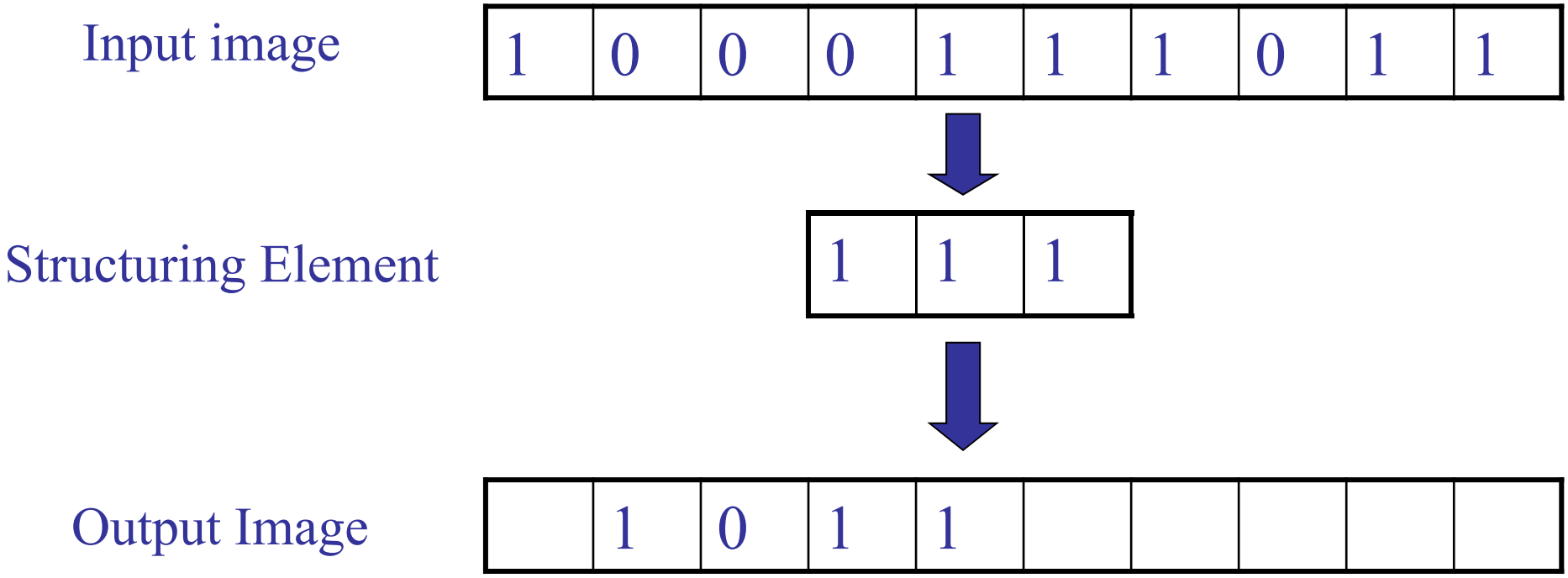
Structuring Element

1	1	1

Output Image

	1	0	1						

Let's do it together!



Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	1	0	1	1	1				

Input image

1	0	0	0	1	1	1	0	1	1

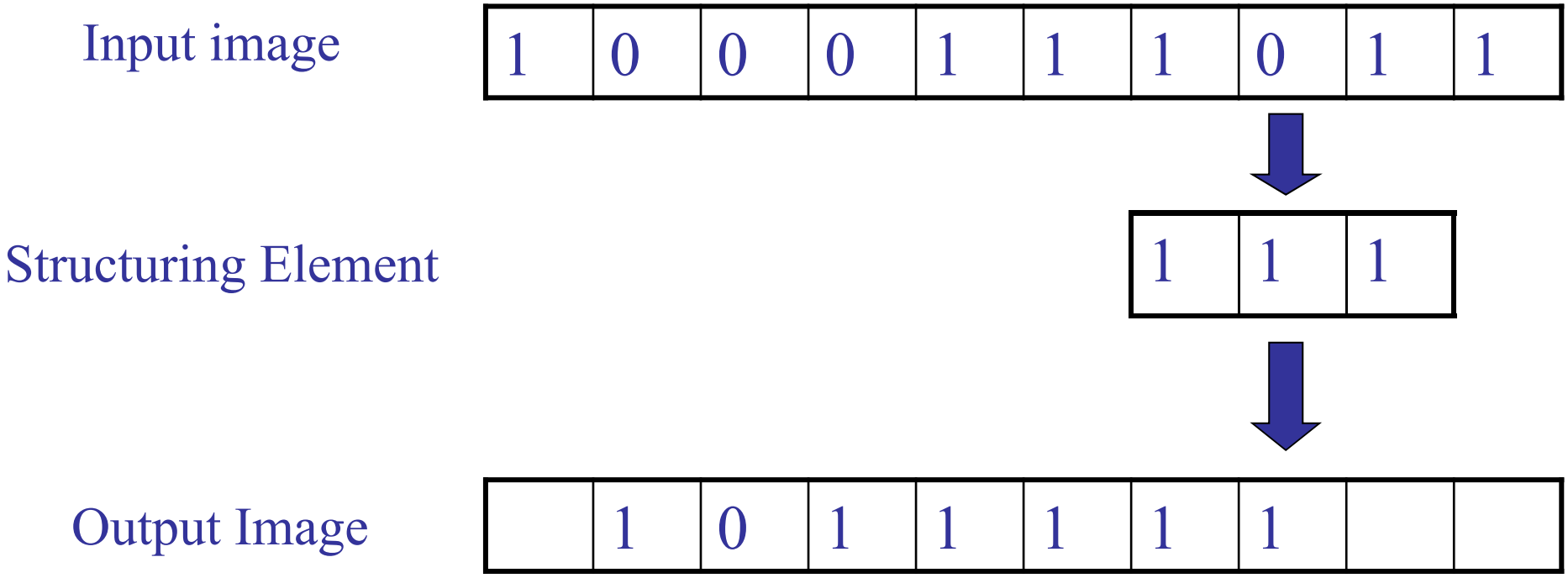
Structuring Element

1	1	1

Output Image

	1	0	1	1	1	1			

Let's do it together!



Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

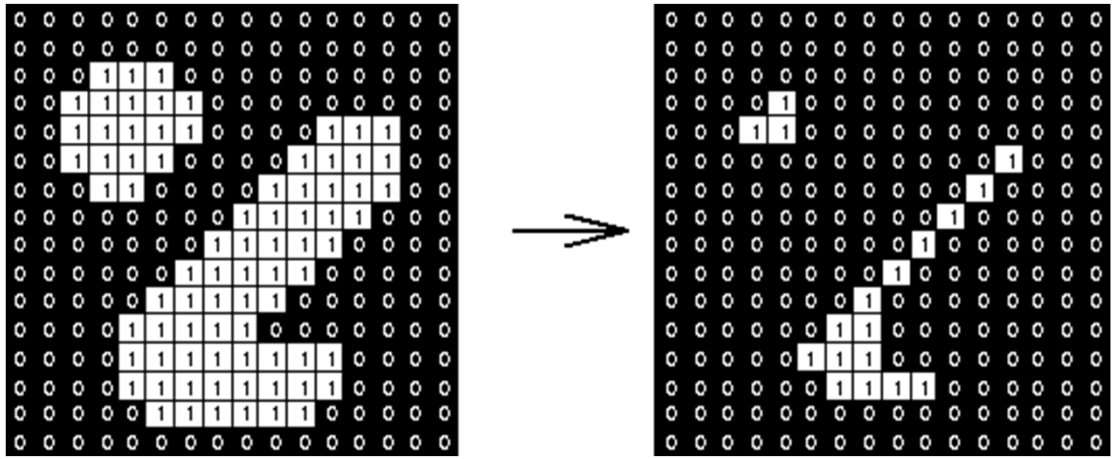
1	1	1

Output Image

	1	0	1	1	1	1	1	1	

Example: Erosion

- **Erosion** is an important morphological operation



- Applied **Structuring Element**:

1	1	1
1	1	1
1	1	1

Set of coordinate points =

{ (-1, -1), (0, -1), (1, -1),
(-1, 0), (0, 0), (1, 0),
(-1, 1), (0, 1), (1, 1) }

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0								

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0	0							

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0	0	0						

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0	0	0	0					

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0	0	0	0	1				

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0	0	0	0	1	0			

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

Output Image

	0	0	0	0	1	0	0		

Input image

1	0	0	0	1	1	1	0	1	1

Structuring Element

1	1	1

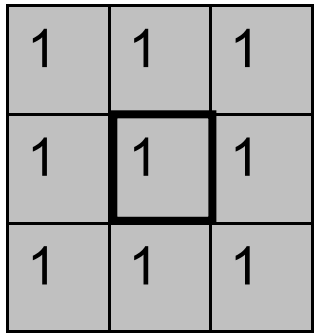
Output Image

	0	0	0	0	1	0	0	0	

DEMO in matlab: DILATION←→EROSION

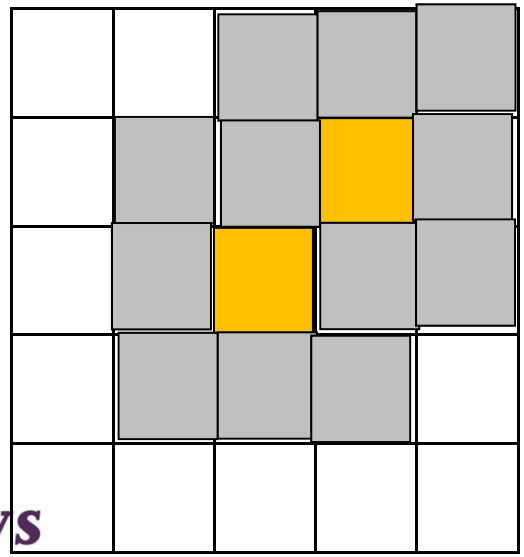
Example: Suppose that the structuring element is a 3x3 square with the origin at its center

$K =$




```
{ (-1,-1), (0,-1), (1,-1),
  (-1,0),  (0,0),  (1,0),
  ( 1,1),  (0,1),  (1,1) }
```

$X =$



Fontys

Opening & Closing

- ✓ derived from the fundamental operations: erosion and dilation
- ✓ normally applied to binary images

Fontys

Opening & Closing

- Opening → An Erosion followed by a dilation
- Closing → A dilation followed by an erosion

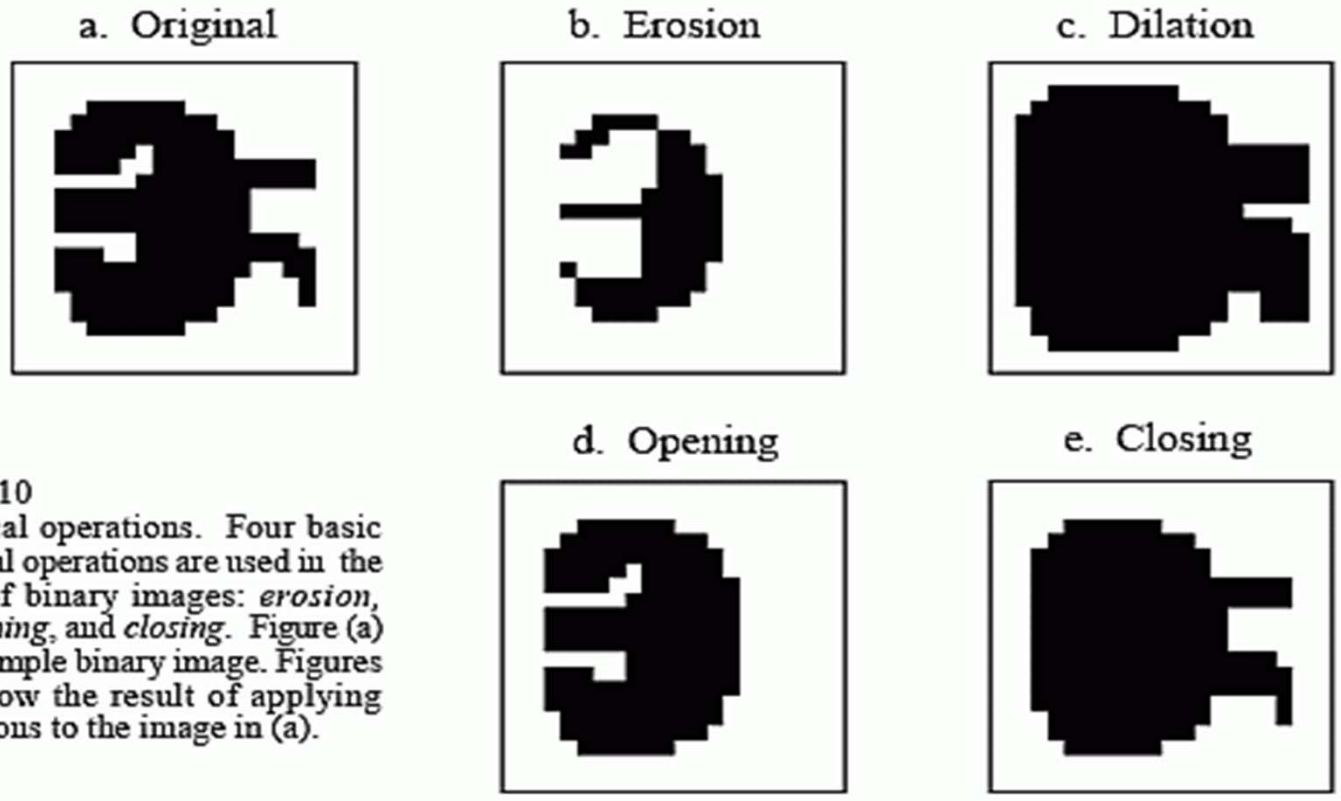
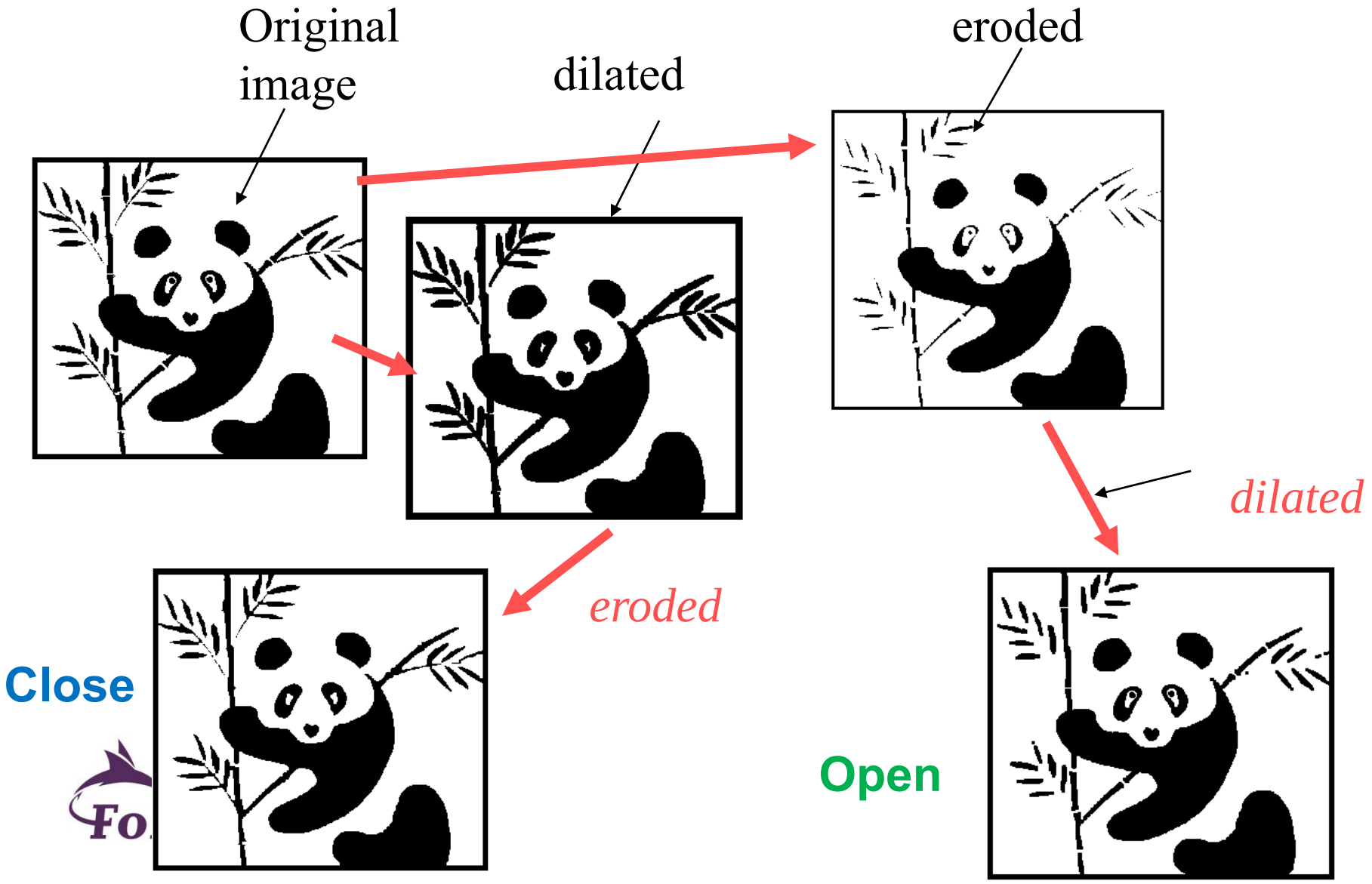
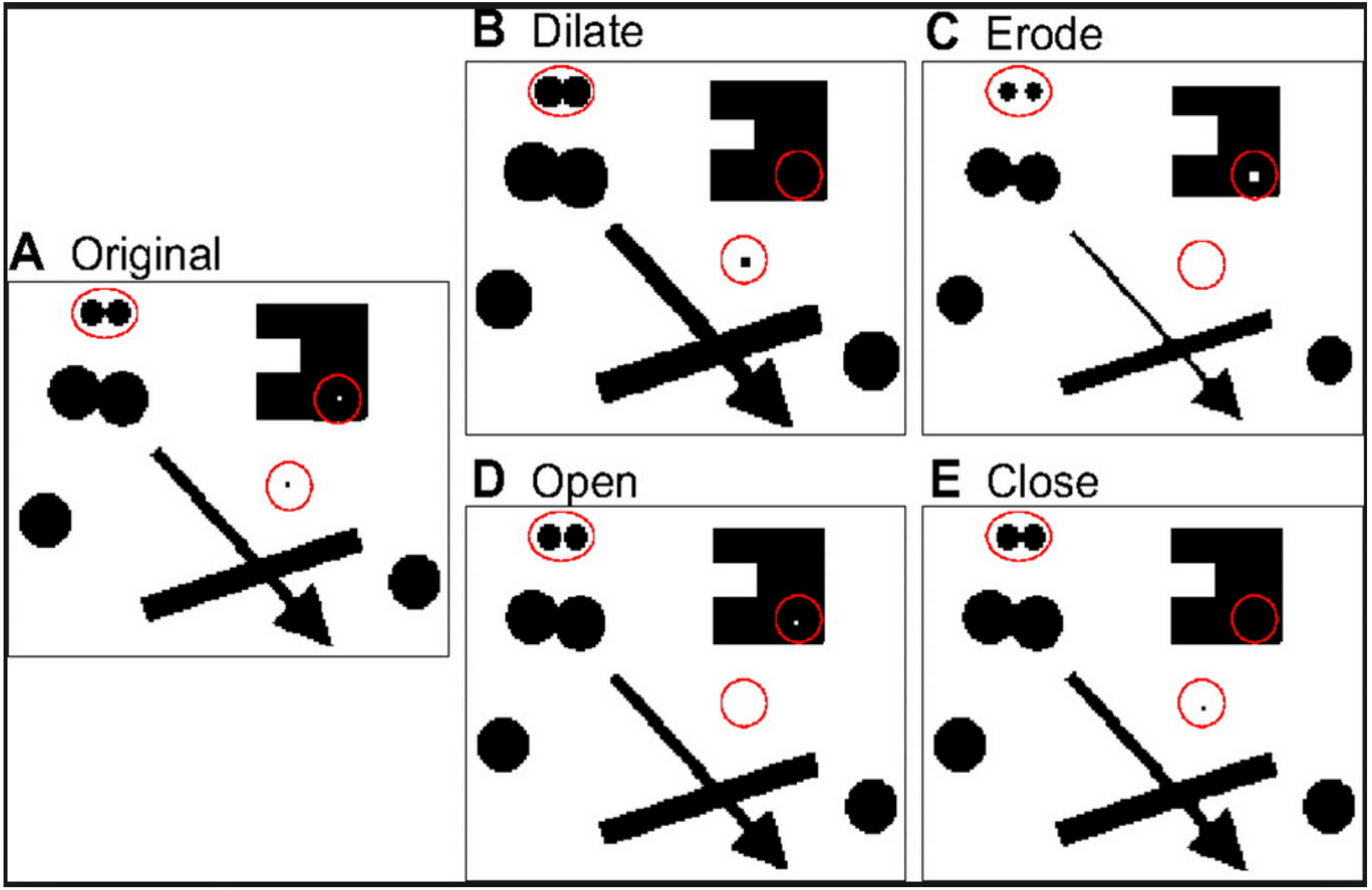


FIGURE 25-10
Morphological operations. Four basic morphological operations are used in the processing of binary images: *erosion*, *dilation*, *opening*, and *closing*. Figure (a) shows an example binary image. Figures (b) to (e) show the result of applying these operations to the image in (a).

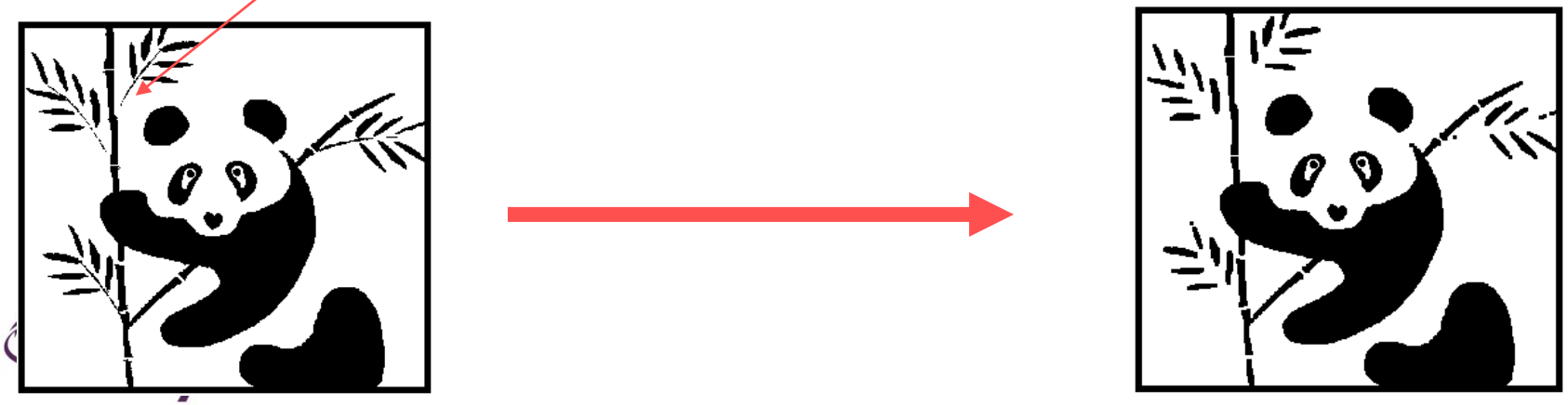
Close = Dilate next Erode
Open = Erode next Dilate




A Original
B Dilate
C Erode
D Open
E Close

Open

- An erosion followed by a dilation
- It serves to eliminate noise
- Does not significantly change an object's size

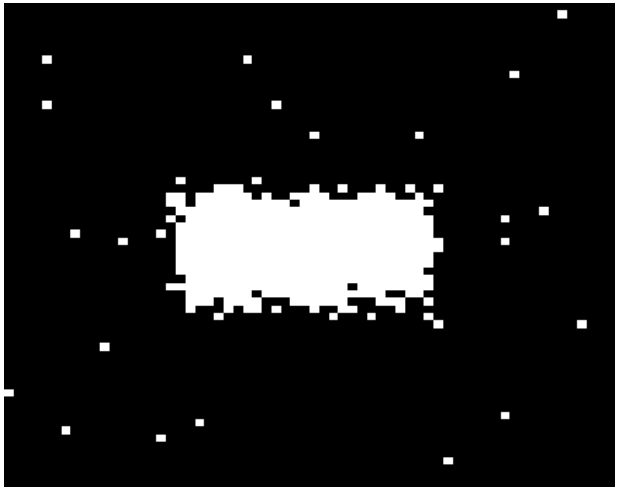


Opening Example

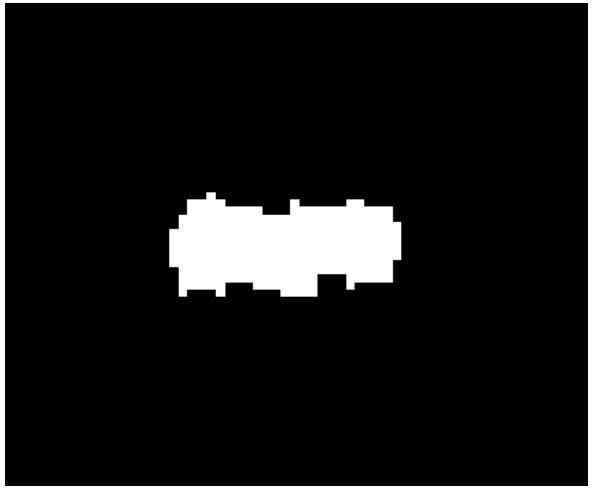
Open = Erode next Dilate

- eliminate noise (isolated pixels)
- smooth boundaries
- object is the same size as in original

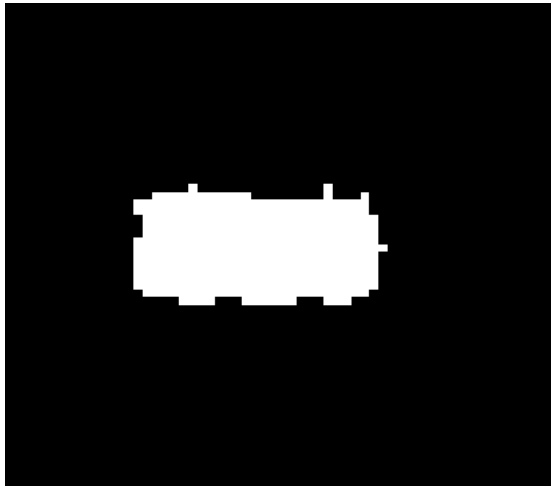
Original



Erode

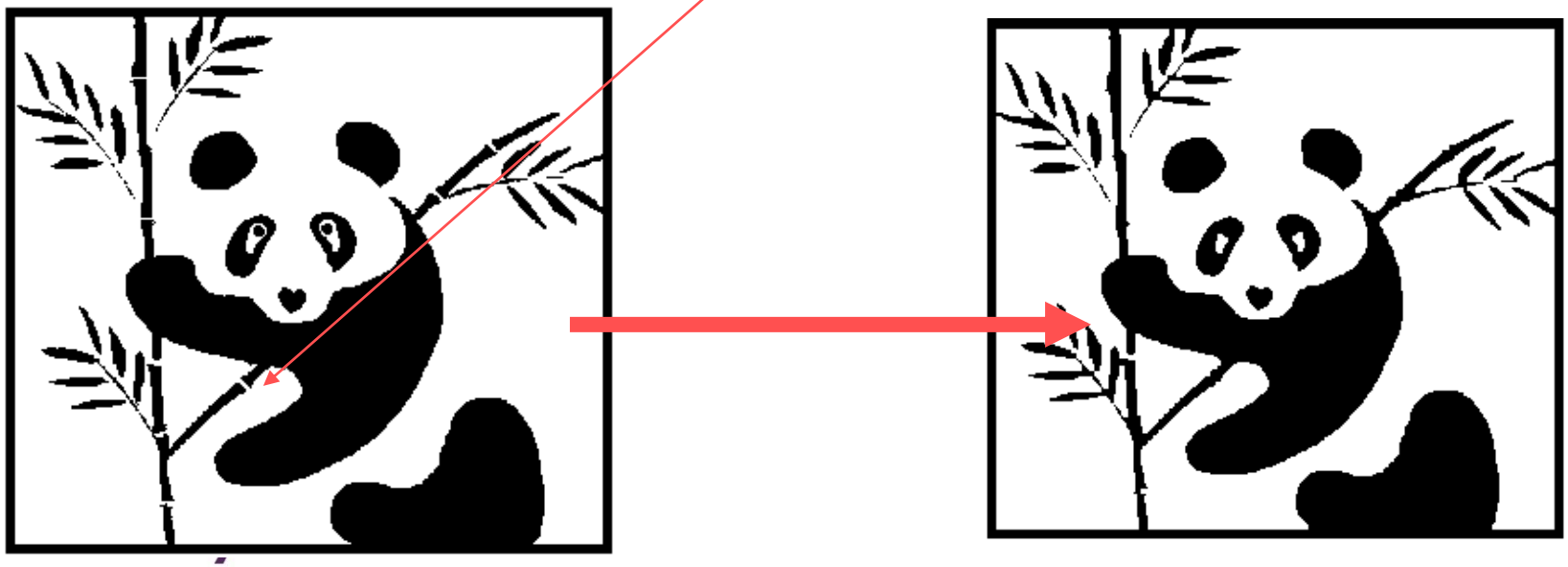


Dilate



Close

- Dilation followed by erosion
- Serves to close up cracks in objects and holes due to pepper noise
- Does not significantly change object size

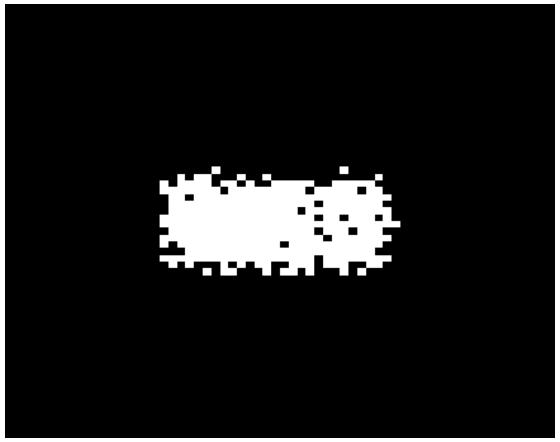


Closing Example

Close = Dilate next Erode

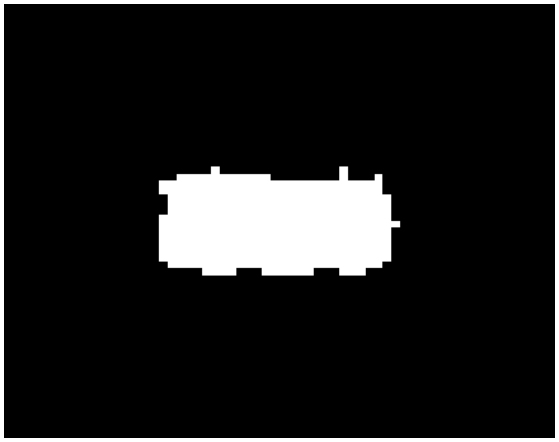
- eliminate noise (holes)
- smooth boundaries
- maintain object size

Original



Dilate

Erode

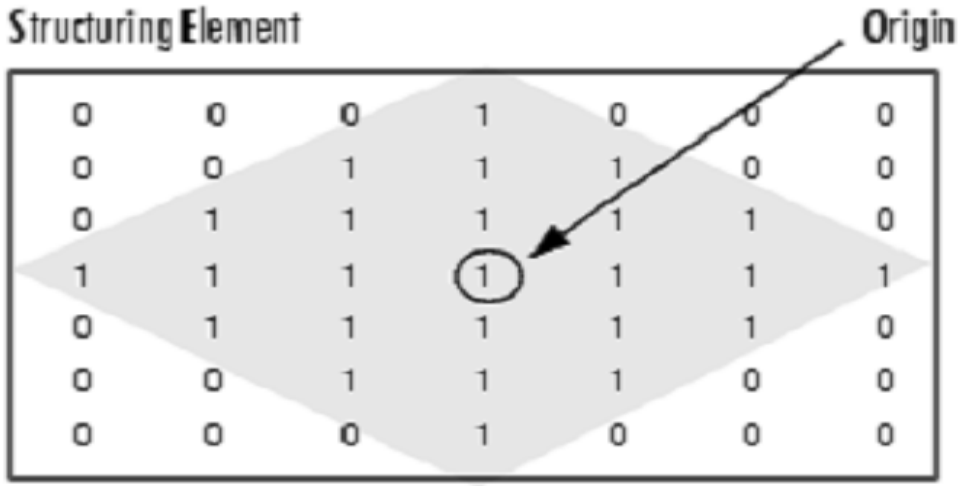


Different view → different way of understanding

Fontys

Diamond-Shaped Structuring Element

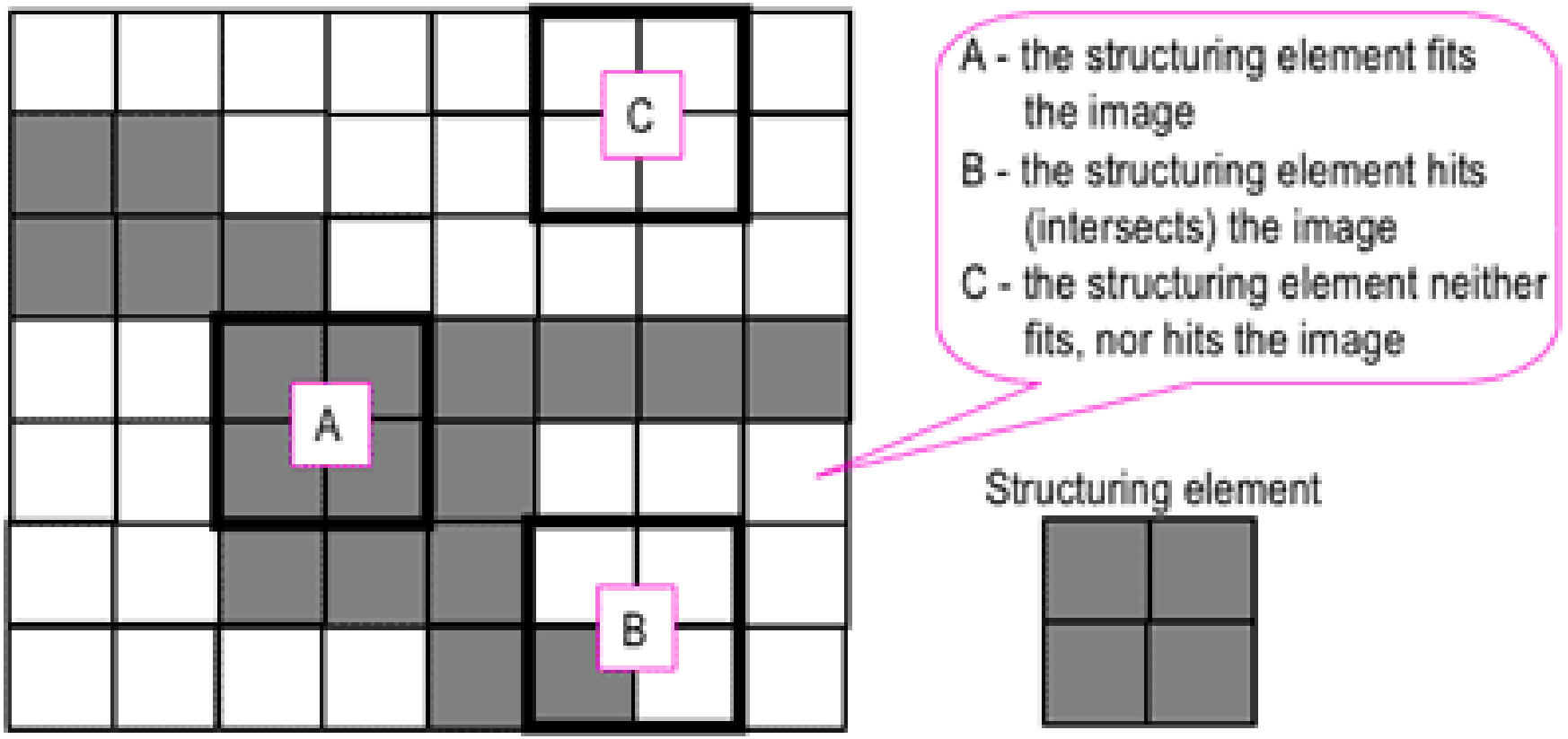
- *Origin:* the center pixel of the structuring element



Fontys

Dilation and erosion operation

- **fit—hit—miss**



Probing of an image with a structuring element
(white and grey pixels have zero and non-zero values, respectively).

Dilation

- Miss ➔ No changes
- Hit ➔ at least one pixel matches =>The origin is replaced by 1

Input matrix

Structuring element

Dilated matrix

Dilation in MATLAB

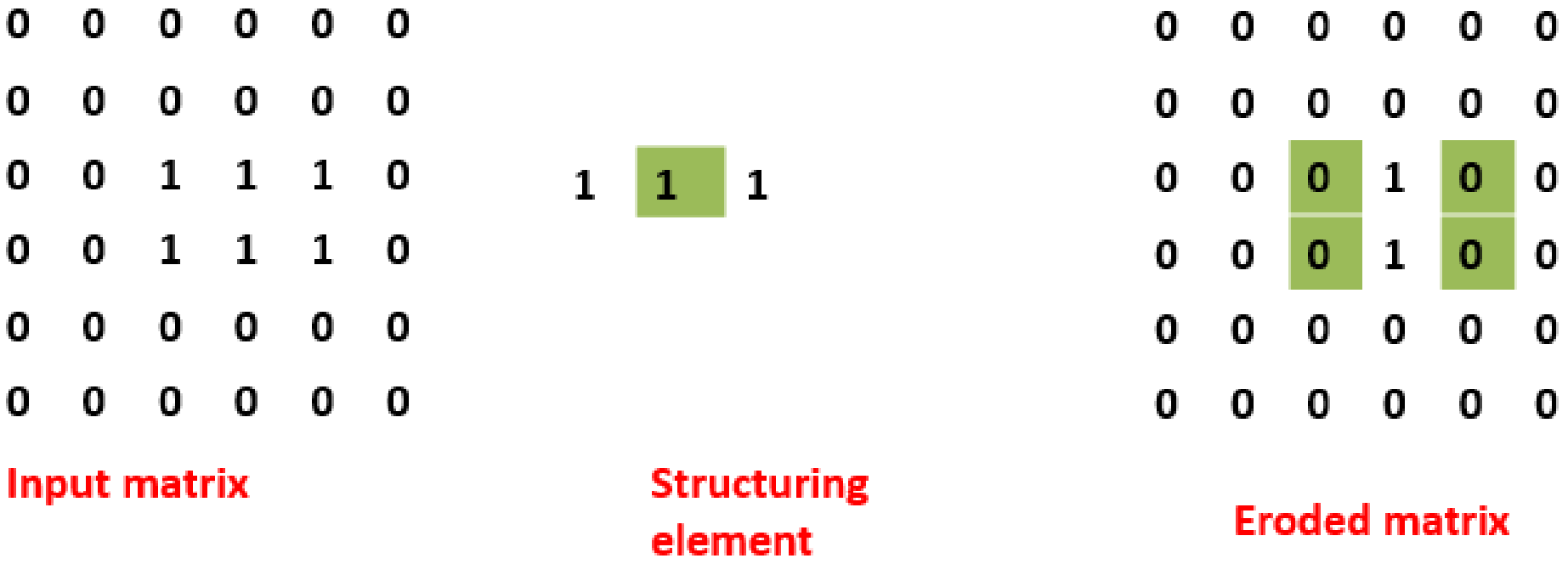
- Dilation Syntax: Y = imdilate(A,B)
  - A ➔ input image
  - B ➔ Structuring element
  - Y ➔Dilated image

- Structuring element in MATLAB
  - using ‘strel’ function:

    se = strel (shape , parameters)
  - shape can be ‘ diamond ’ , ’ square ’ , ’ disk ’ , ’ line ’ etc.

Erosion in MATLAB

- It shrinks or thin objects in a binary image
- Syntax se =imerode(A,B)
- Output is 1 when element completely fits



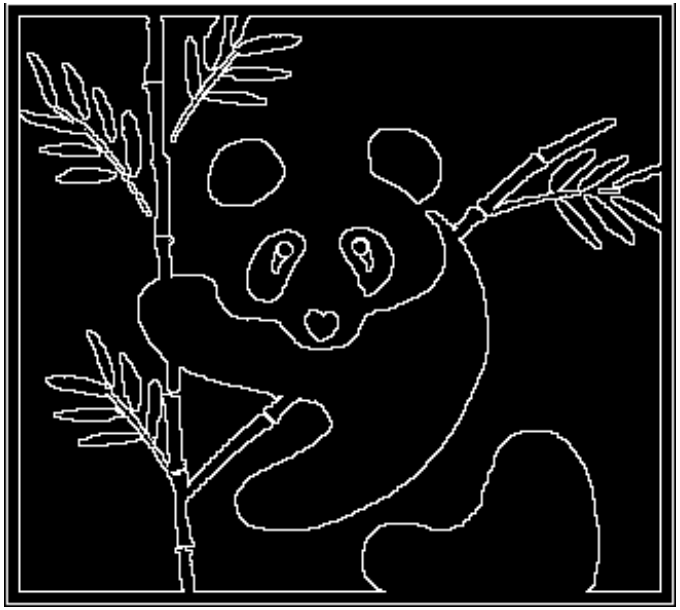
Morphological Operations: Matlab

- In Matlab→ help “Morphological Operations

Bonus:

Edge detection

Dilate - original



This subtraction is set theoretical

Now you need to invert the image

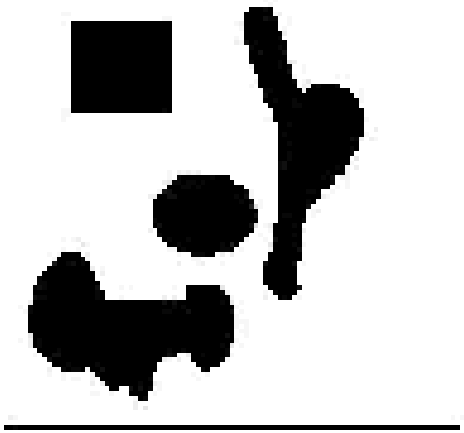
There are more methods for edge detection

Fontys

Binary image contour extraction

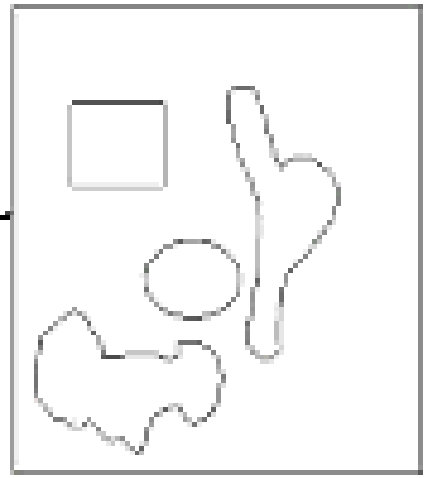
Erode and Binary Contour in Matlab

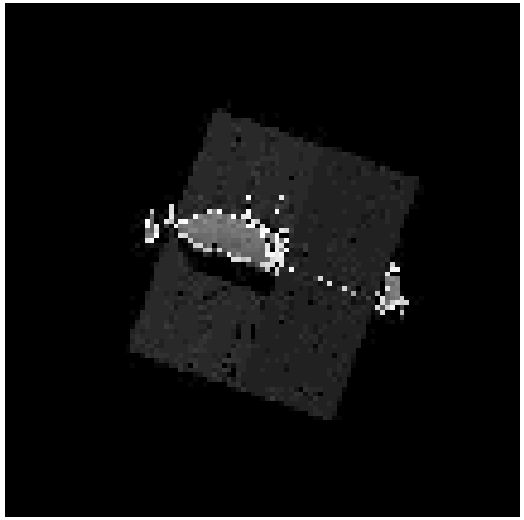
image



```
Erosed=erode(image);
Contour=
  double(image)-double(Erosed);
Contour=~Contour;
```

Contour





Satellite image with contour.

Erosion can be used to find contour

Dilation can be also used for it - think how?

Morphological Processing of Handwritten Digits

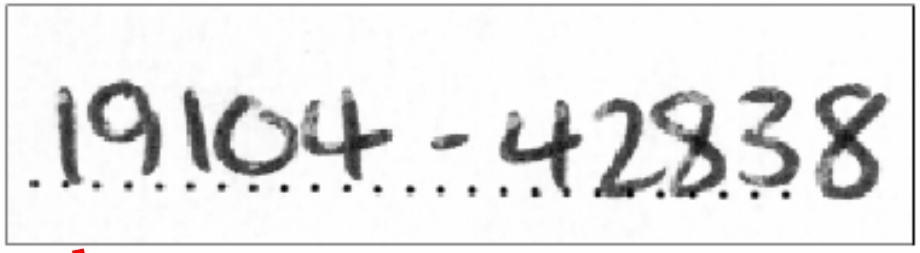
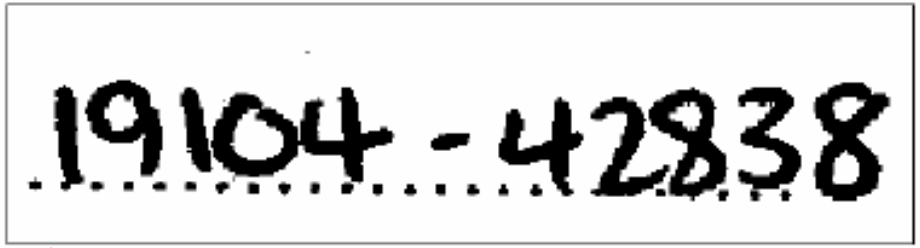


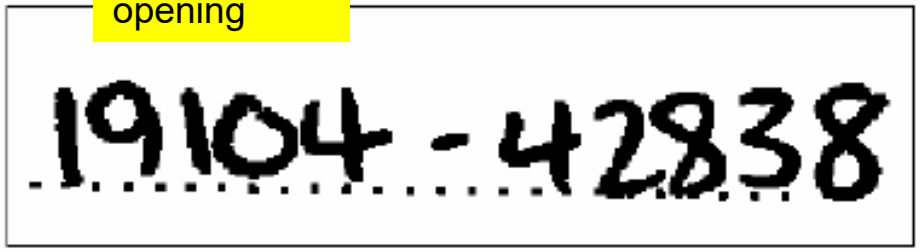
image I

thresholding



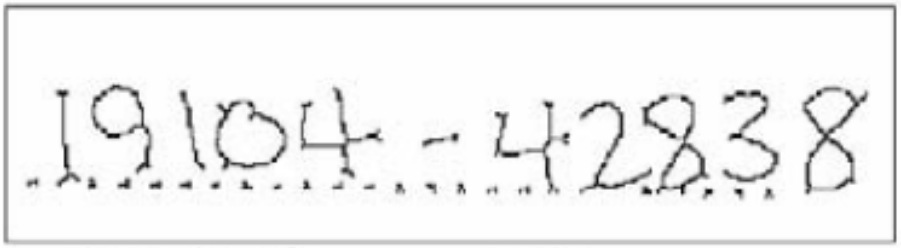
$X = (I < 245)$

opening



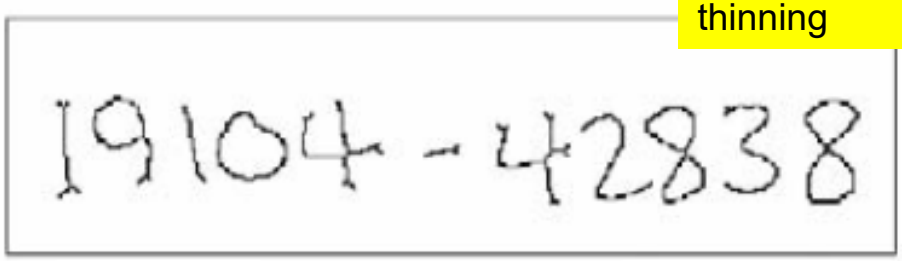
$Y = X \circ S_{3,3}$

$S_{3,3} =$ 



$Y \oslash \{L_i\}_{i=1}^{8}$, repeat till convergence

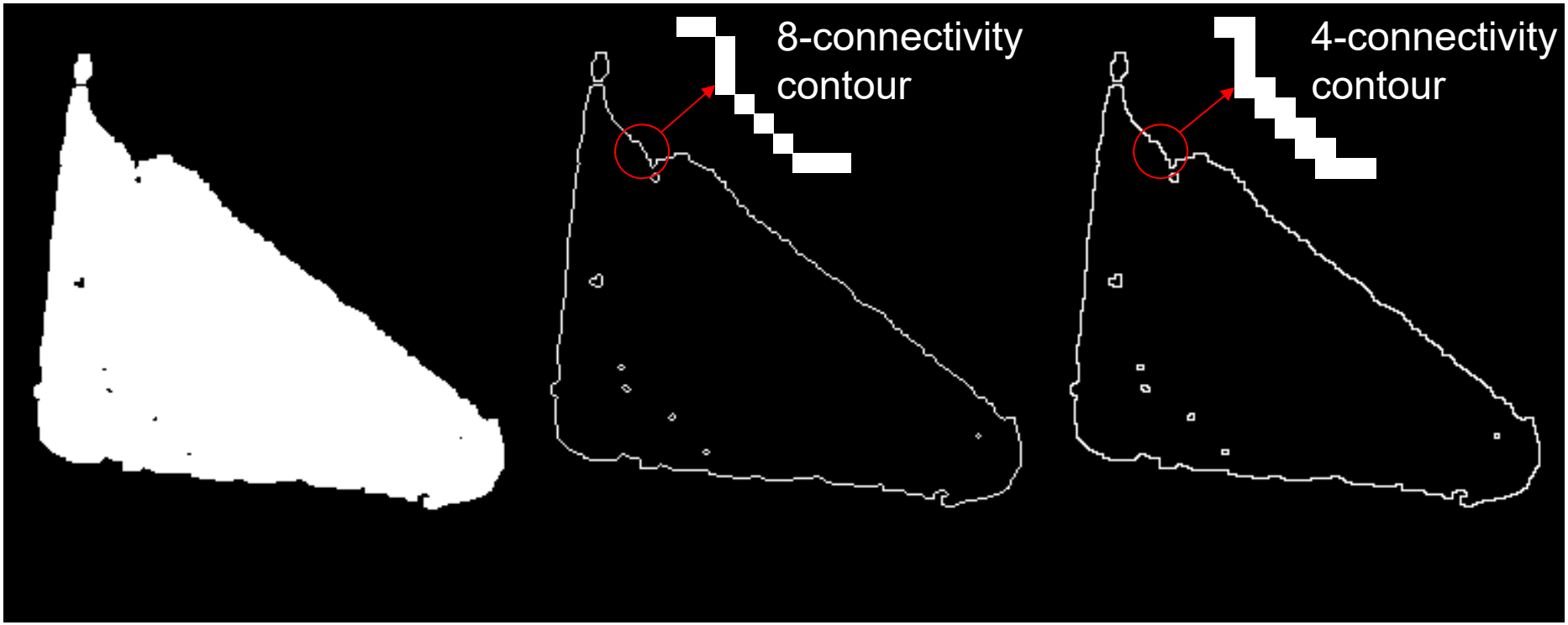
thinning



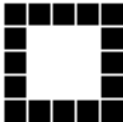
smoothed skeleton

smoothing

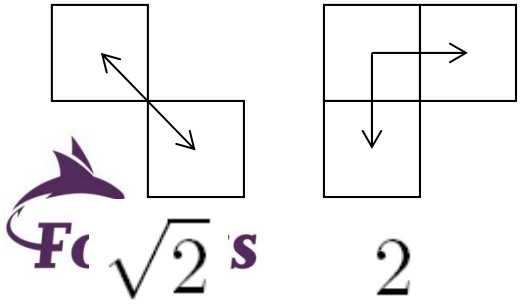
CONTOURS with different connectivity patterns



4-connectivity



8-connectivity



Important for perimeter computation.