UNIVERSIDAD PANAMERICANA

Mecatrónica y Control de Sistemas

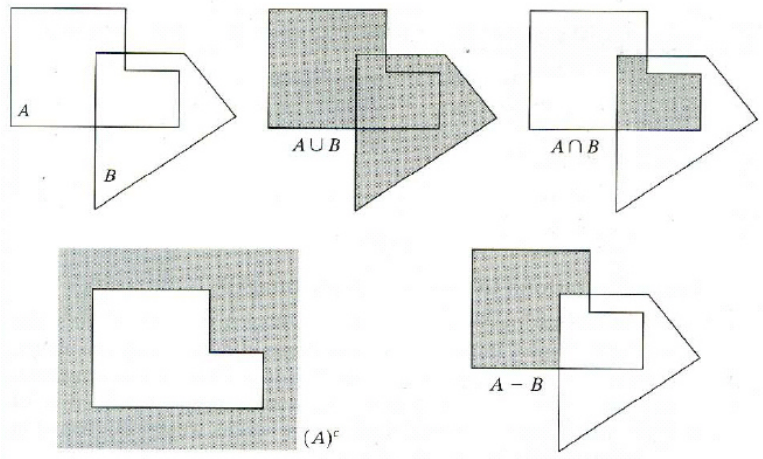
Morphology

Material de clase: **http://www.robotica-up.org/CV2018.zip**

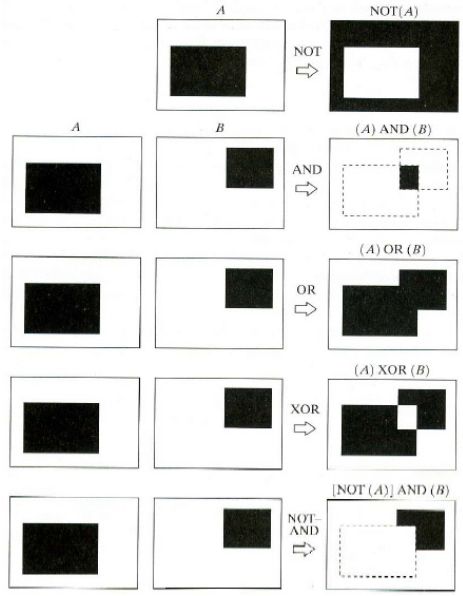
Introduction

What is morphology?

It is a tool for extracting components of an image (such as regions, contours, skeletons,…) which are useful in shape representation and description. Morphological processing is based on the set theory.



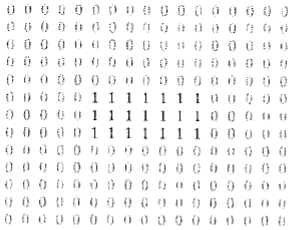
Set Theory - Examples

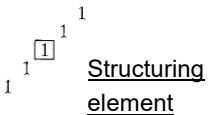


Dilation ($A \oplus B$)

Grows/thickens objects in a binary image. It is based on a structuring element.

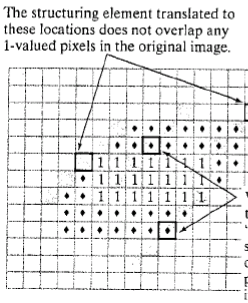
Original



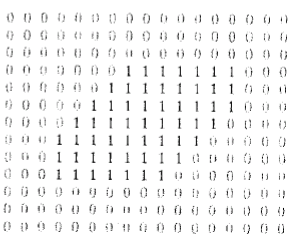


Structuring element

Dilation process



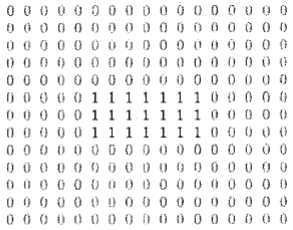
Final



Erosion ($A \ominus B$)

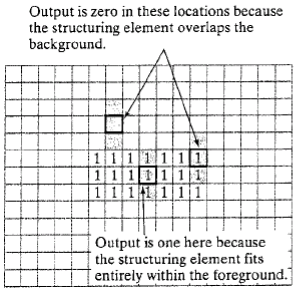
Shrinks/thins objects in a binary image.

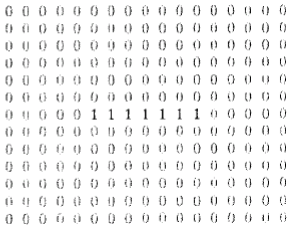
Original



Structuring element

Erosion process





Final

Implementation – Structuring Element

s=strel('option',R)

'diamond' - creates a flat diamond-shaped structuring element with the specified size, R. R is the distance from the structuring element origin to the points of the diamond. R must be a nonnegative integer scalar.

'disk' - creates a flat disk-shaped structuring element with the specified radius, R. R must be a nonnegative integer.

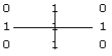
'line' - creates a flat linear structuring element

'octagon' - creates a flat octagonal structuring element

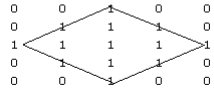
Others

'pair' , 'periodicline', 'rectangle', square'

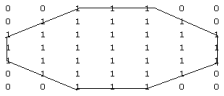
R=1



R=2



R=3



Help strel …. for details

Opening and closing

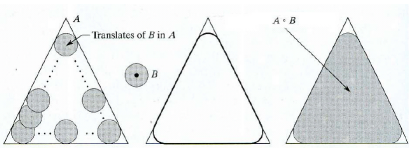
Opening: Removes completely regions of an object that cannot contain the structuring element, smooths object contours, breaks thin connections and removes thin protrusions

$$A \circ B = (A \ominus B) \oplus B$$

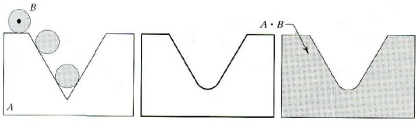
Closing: Also tends to smooth object contours. Joins narrow breaks and fills holes smaller than the structuring element.

$$A \bullet B = (A \oplus B) \ominus B$$

Geometric interpretation



Opening



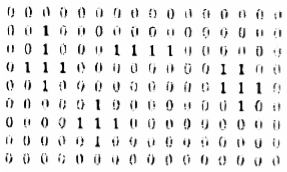
Closing

Hit-or-Miss Transformation ($A \otimes B$)

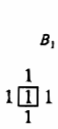
Objective: To detect pixel configurations in an image upon the use of the background information.

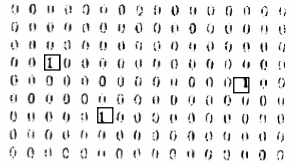
$$A \otimes B = (A \ominus B_1) \cap (A^c \ominus B_2)$$

A

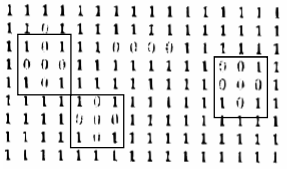


B_1

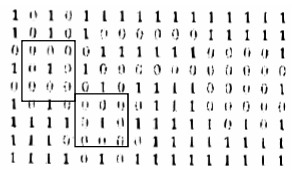


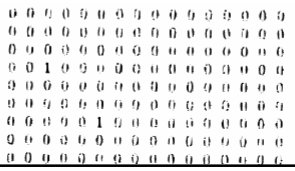


A^c



B_2





The final image consists of all locations that match the pixels in B1 (a “hit”) and none of the pixels in B2 (a “miss”)

Morphological Algorithms

Border extraction $\beta(A) = A - (A \ominus B)$

Region filling $X_k = (X_{k-1} \oplus B) \cap A^c \quad k = 1, 2, 3, \ldots$

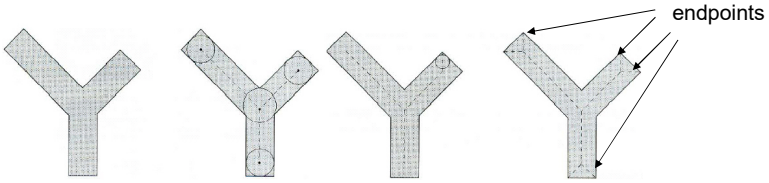
A: imagen to be filled (M,N)

B: structuring element

X_k: image (M,N) of "0" with a starting point "1"

The algorithm ends at interaction *k* if $X_k = X_{k-1}$

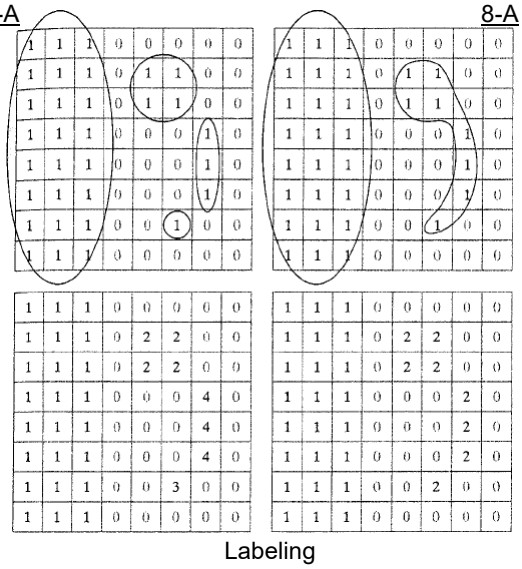
Skeletons



(a) (b) (c) (d)

Morphological Algorithms – Connected Elements

4-A 8-A



Labeling

Objective: Object detection

[L,num]=bwlabel(f,conn)

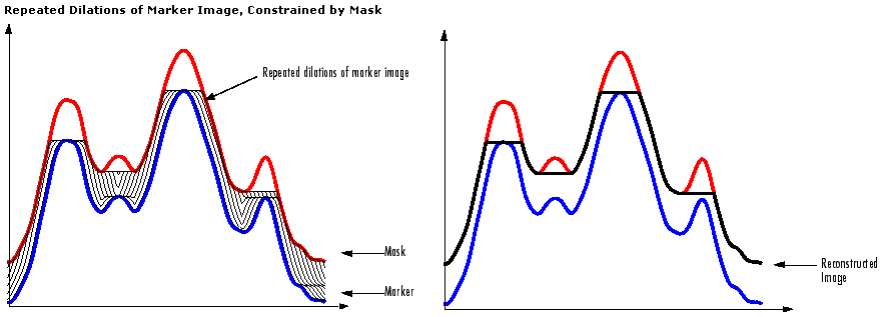
f – Input binary image

Conn – desired connectivity (default 8)

L – Label matrix

Num – total number of connected elements

Morphological Algorithms –Morphological Reconstruction



Morphological reconstruction is based on an erosion with the following properties:

- It requires 2 images and one structuring element (instead of one image and one structuring element)
- Image 1 (f) is the *marker* (the starting point of the transformation)
- Image 2 (g) is the *mask* (the original image, the end of the transformation)

Morphological Algorithms –Morphological Reconstruction

Mask (original image)

```
A = [10   10   10   10   10   10   10   10   10   10;
     10   14   14   14   10   10   11   10   11   10;
     10   14   14   14   10   10   10   11   10   10;
     10   14   14   14   10   10   11   10   11   10;
     10   10   10   10   10   10   10   10   10   10;
     10   11   10   10   10   18   18   18   10   10;
     10   10   10   11   10   18   18   18   10   10;
     10   10   11   10   10   18   18   18   10   10;
     10   11   10   11   10   10   10   10   10   10;
     10   10   10   10   10   10   11   10   10   10];
```

recon = imreconstruct(marker, mask)

(Reconstructs an image by eliminating all fluctuations and keeping the desired information.

```
recon =
    10   10   10   10   10   10   10   10   10   10
    10   12   12   12   10   10   10   10   10   10
    10   12   12   12   10   10   10   10   10   10
    10   12   12   12   10   10   10   10   10   10
    10   10   10   10   10   10   10   10   10   10
    10   10   10   10   10   16   16   16   10   10
    10   10   10   10   10   16   16   16   10   10
    10   10   10   10   10   16   16   16   10   10
    10   10   10   10   10   10   10   10   10   10
    10   10   10   10   10   10   10   10   10   10
```

Marker (Mask $\ominus$ Structuring element)

(Highlights the desired locations)

```
marker =
     8    8    8    8    8    8    8    8    8    8
     8   12   12   12    8    8    9    8    9    8
     8   12   12   12    8    8    8    9    8    8
     8   12   12   12    8    8    9    8    9    8
     8    8    8    8    8    8    8    8    8    8
     8    9    8    8    8   16   16   16    8    8
     8    8    8    9    8   16   16   16    8    8
     8    8    9    8    8   16   16   16    8    8
     8    9    8    9    8    8    8    8    8    8
     8    8    8    8    8    8    9    8    8    8
```

Filling holes

B=imfill(A,'holes')

Remove objects at borders

B=imclearborder(A,conn)

Morphology in gray-level Images

Dilation
Erosion
Opening
Closing

} Same as binary

Morphological Gradient (change of gray-level in an image

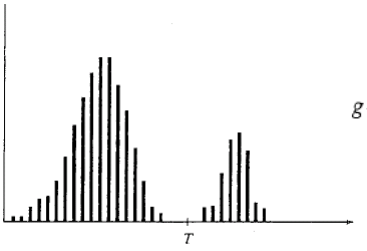
$$A \oplus B - A \ominus B$$

Top-hat transformation: Background equalization

$$h = f - (f \circ b)$$

Reconstruction: Better binarize the image first and work in binary

Binarization by Threshold Selection



$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) \geq T \\ 0 & \text{if } f(x, y) < T \end{cases}$$

$f(x, y) \geq T$ ← Object

$f(x, y) < T$ ← Background

T=graythresh(f);