Binary Image Analysis: Part 2
Readings: Chapter 3: 3.5-3.7

- mathematical morphology
- region properties
- region adjacency

Mathematical Morphology

Binary mathematical morphology consists of two basic operations

dilation and erosion

and several composite relations

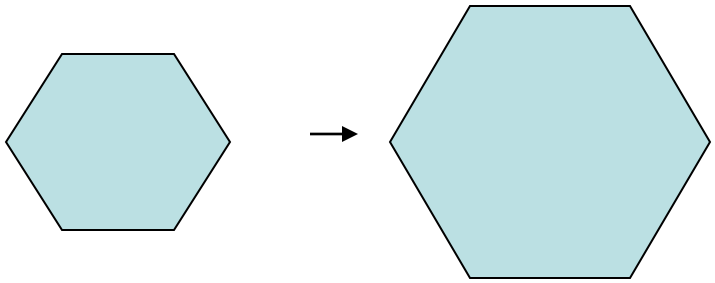
closing and opening
conditional dilation
. . .

Dilation

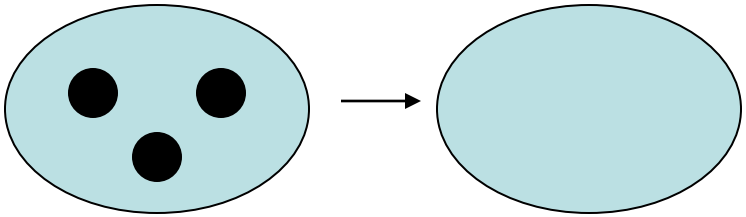
Dilation expands the connected sets of 1s of a binary image.

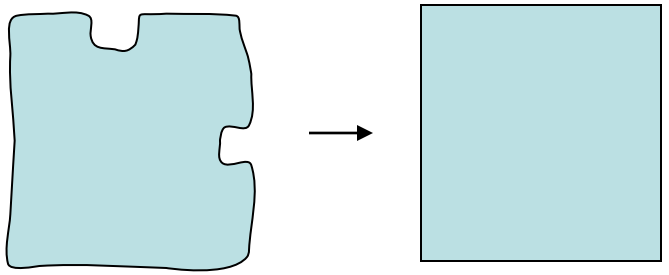
It can be used for

1. growing features



2. filling holes and gaps



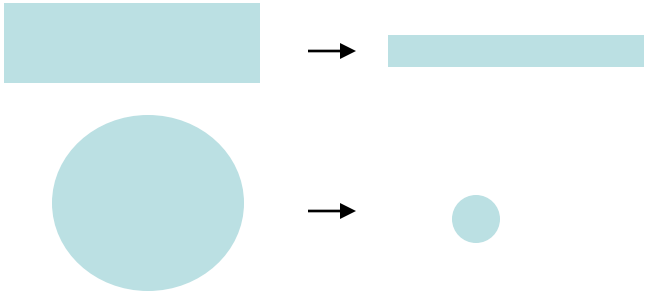


Erosion

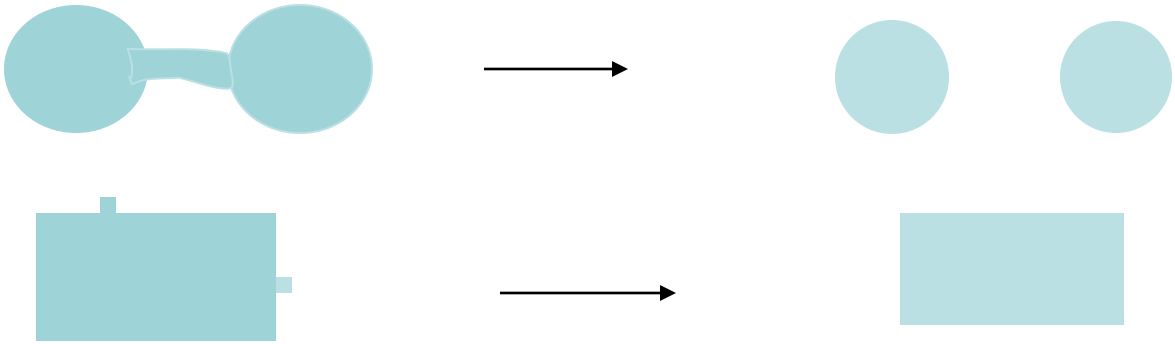
Erosion shrinks the connected sets of 1s of a binary image.

It can be used for

1. shrinking features



2. Removing bridges, branches and small protrusions

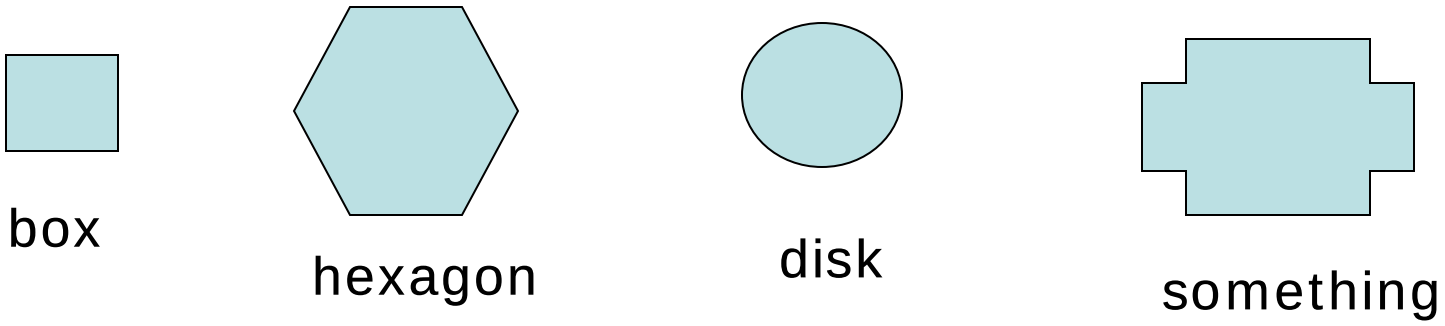


Structuring Elements

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.

The origin is usually the center if the structuring element is symmetric.



box(length,width)

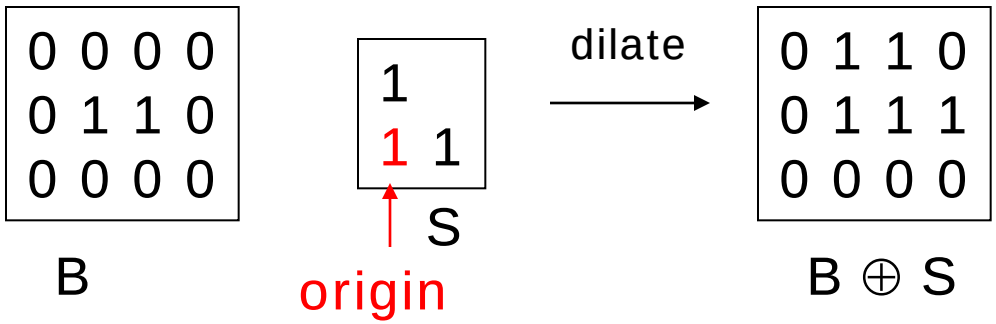
disk(diameter)

Dilation with Structuring Elements

The arguments to dilation and erosion are

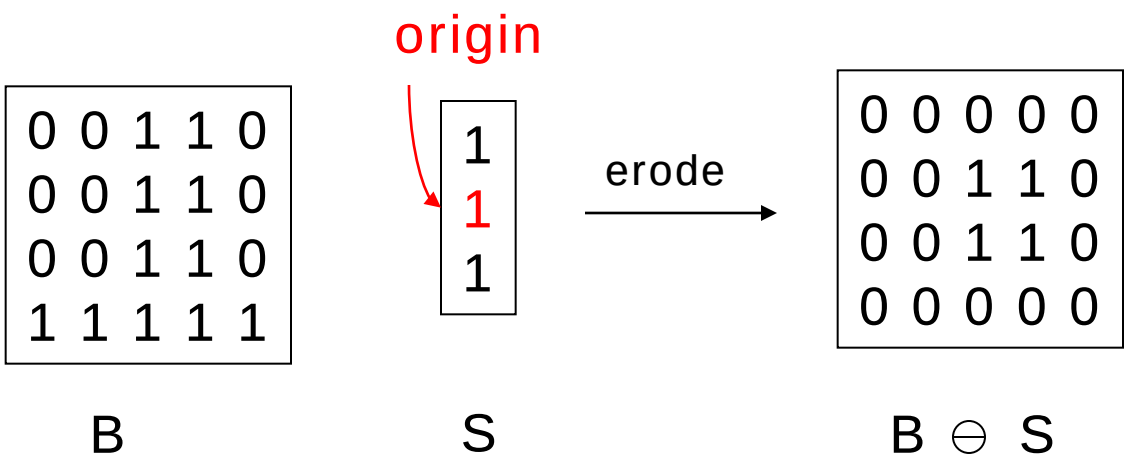
1. **a binary image B**
2. **a structuring element S**

dilate(B,S) takes binary image B, places the origin of structuring element S over each 1-pixel, and ORs the structuring element S into the output image at the corresponding position.

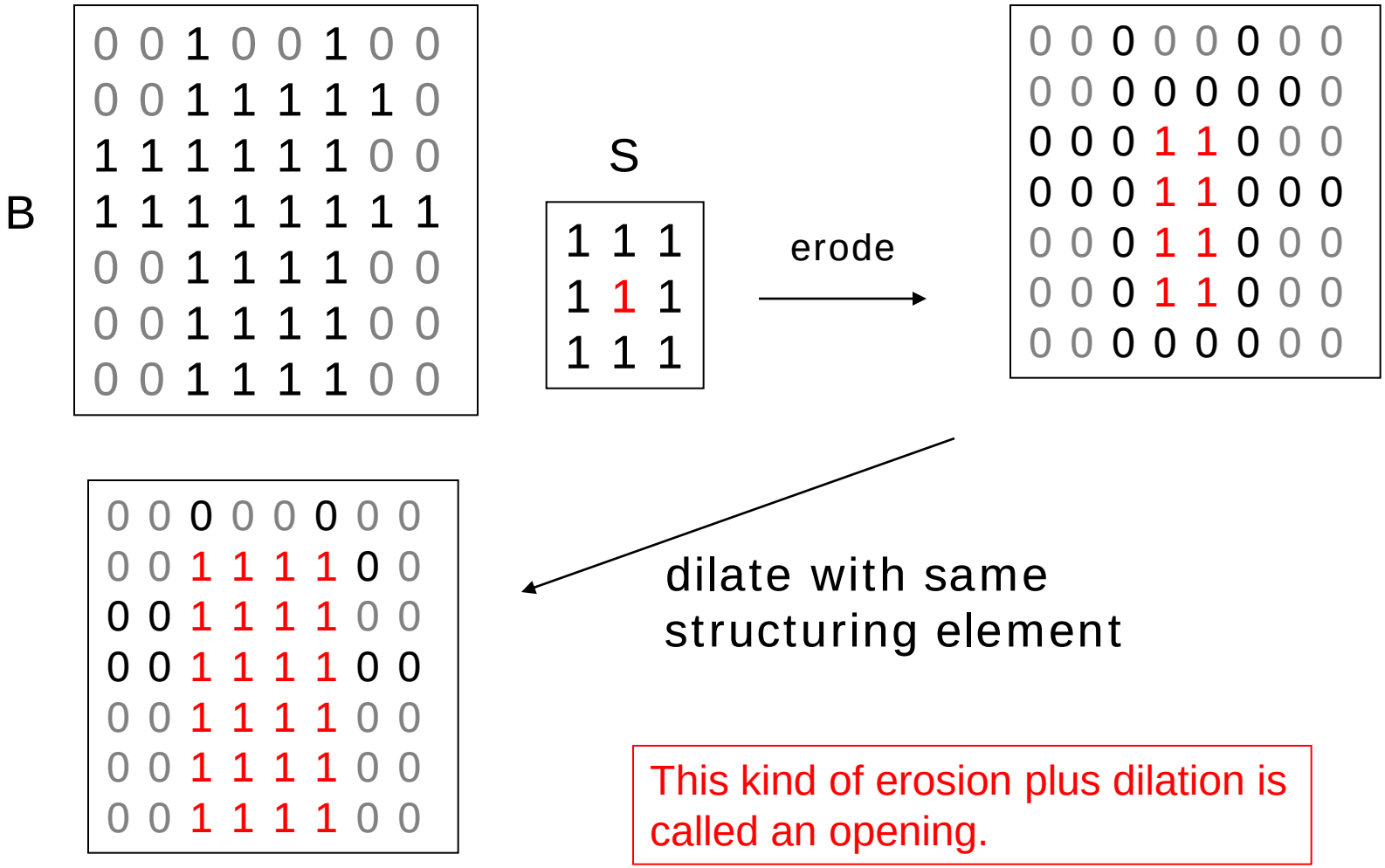


Erosion with Structuring Elements

erode(B,S) takes a binary image B, places the origin of structuring element S over every pixel position, and ORs a binary 1 into that position of the output image only if every position of S (with a 1) covers a 1 in B.



Example to Try



This kind of erosion plus dilation is called an opening.

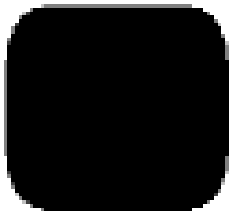
Opening and Closing

- Closing is the compound operation of dilation followed by erosion (with the same structuring element)

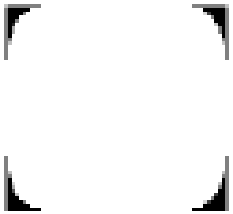
- Opening is the compound operation of erosion followed by dilation (with the same structuring element)

Use of Opening

Original



Opening

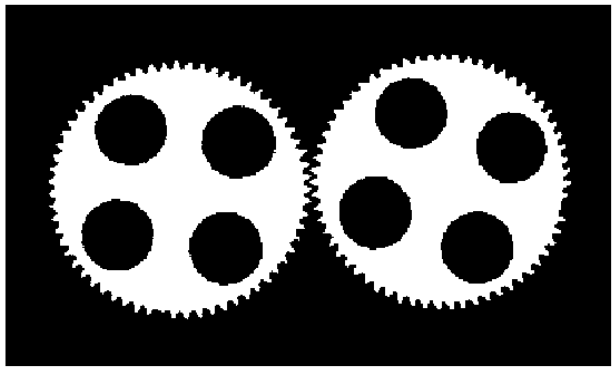


Corners

What kind of structuring element was used in the opening?

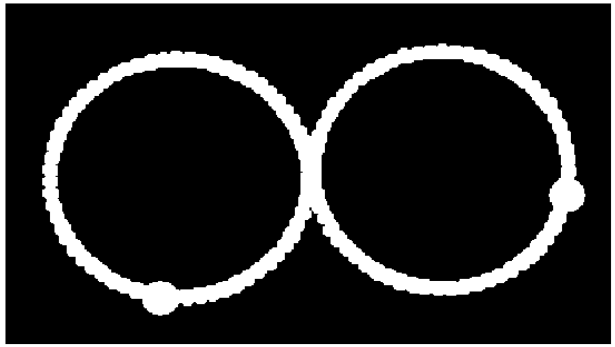
How did we get the corners?

Gear Tooth Inspection



original
binary
image

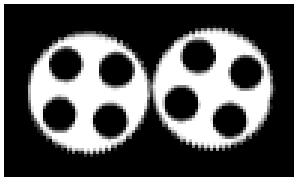
How did
they do it?



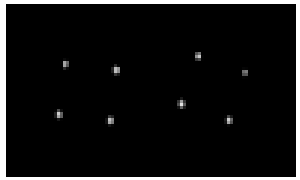
detected
defects

Some Details (see Ch 3)

1. Original image



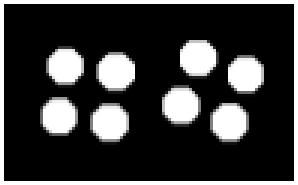
a) original image B



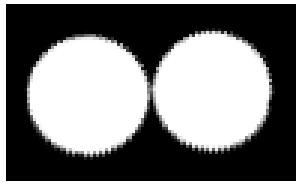
b) B1 = B ⊖ hole_ring

2. Find centers of holes by erosion with a circular ring element

3. Dilate by a hexagon mask



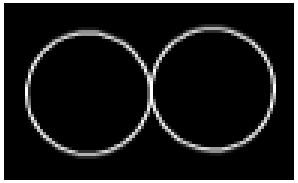
c) B2 = B1 ⊕ hole_mask



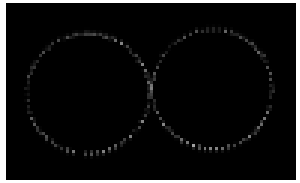
d) B3 = B OR B2

4. OR the hexagons into the original

5. Use disc the size of the body, open to remove teeth. Dilate. Subtract.



e) B7 (see text)

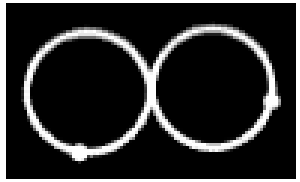


f) B8 = B AND B7

6. AND result of 5 with 1 to get just the teeth.

7. Dilate 6 with a small element that leaves the defects as holes

g) B9 = B8 ⊕ tip_spacing



h) RESULT = ((B7 - B9) ⊕ defect_size) OR B9

7. Show defects in red for customer

Region Properties

Properties of the regions can be used to recognize objects.

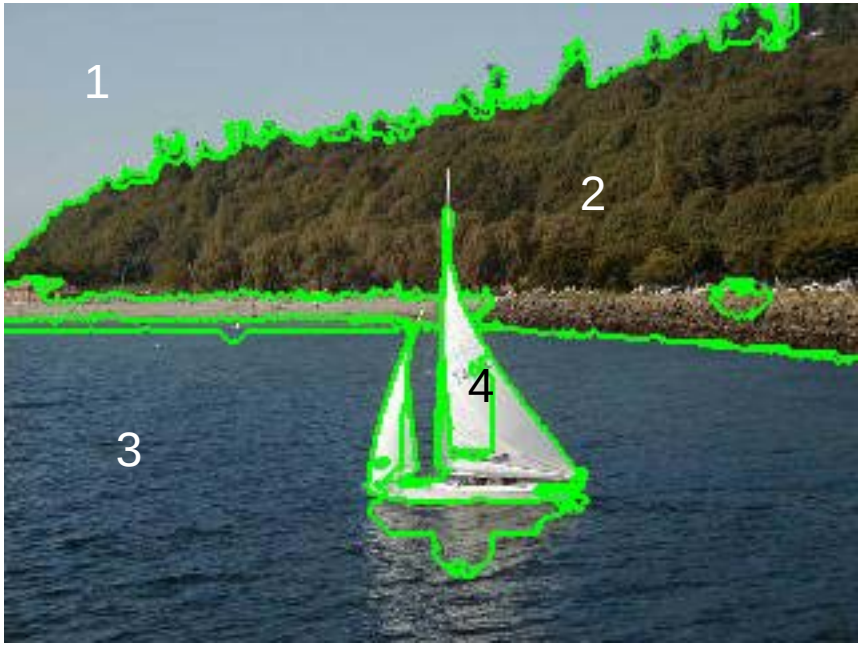
- **geometric properties (Ch 3)**
- **gray-tone properties**
- **color properties**
- **texture properties**
- **shape properties (a few in Ch 3)**
- **motion properties**
- **relationship properties (1 in Ch 3)**

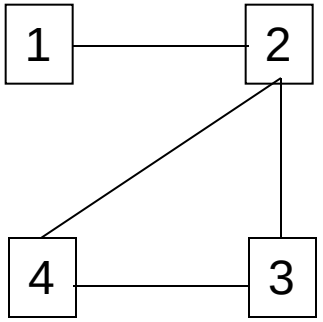
Geometric and Shape Properties

- area
- centroid
- perimeter
- perimeter length
- circularity
- elongation
- mean and standard deviation of radial distance
- bounding box
- extremal axis length from bounding box
- second order moments (row, column, mixed)
- lengths and orientations of axes of best-fit ellipse

Region Adjacency Graph

A region adjacency graph (RAG) is a graph in which each node represents a region of the image and an edge connects two nodes if the regions are adjacent.





What’s all this for?

Once regions are identified and their properties and relationships computed, we can start using them for higher-level tasks such as:

- inspection
- object recognition
- image matching
- classification in general