Binary image processing

Morphological Operations

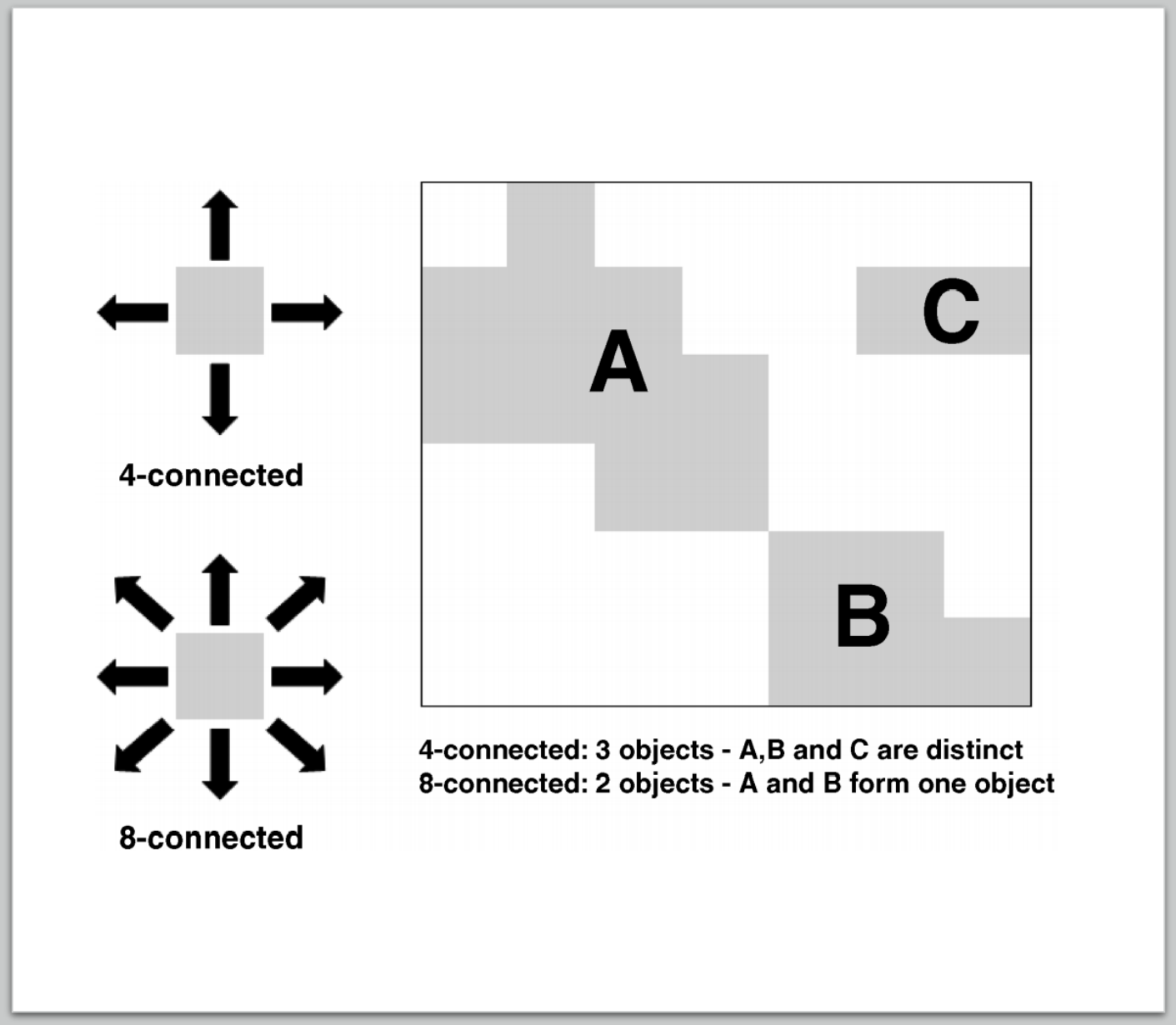
Image segmentation

Binary images

- Black and white images of logical type.
- By convention, white is the foreground, black is the background.
- Logical operations and settheory can be applied:
  - Intersection, with AND operator
  - Union, with OR operator
  - Inversion, with NOT operator
  - Difference, with MINUS operator
- Binary images are a result of many image segmentation operations.
- It is useful to detect and label connected components in a binary image.

Connected components

- Contiguous regions of white pixels.
- Also called “blobs”.
- 4-pixel adjaceny or 8-pixel adjacency.
- Labeling: assigning different numbers to different connected components.
- Matlab functions: *bwconncomp, labelmatrix, label2rgb*

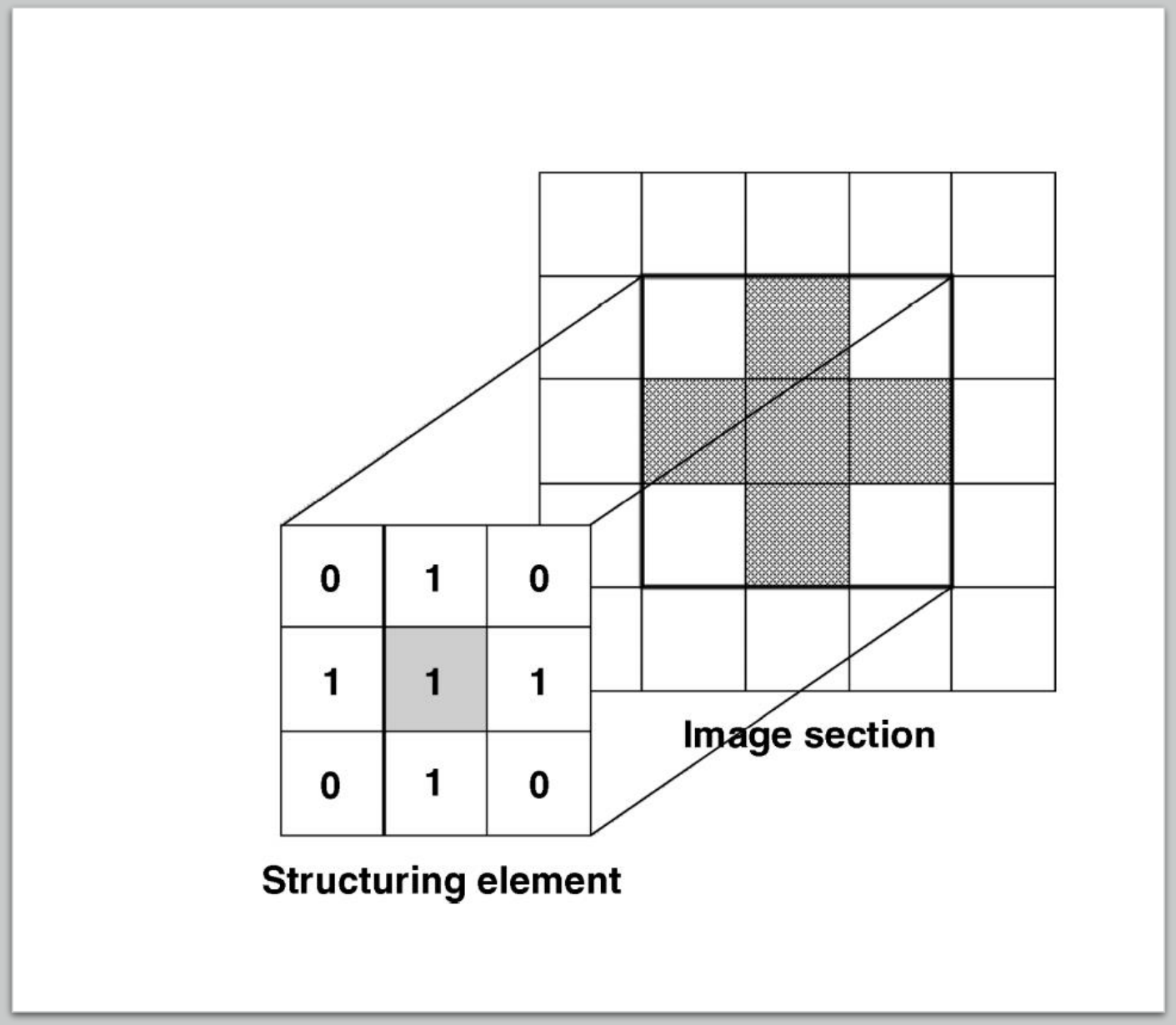


Region properties

- Compute various statistics regarding **shape, size and location** for each blob:
  - Area, perimeter, centroid, standard deviation, bounding box, circularity, etc.
- Count the number of blobs.
- Matlab function : *regionprops*
- The number of blobs is equal to the size of the structure array returned by regionprops function.
- Or equal to the maximum label number in the label image.

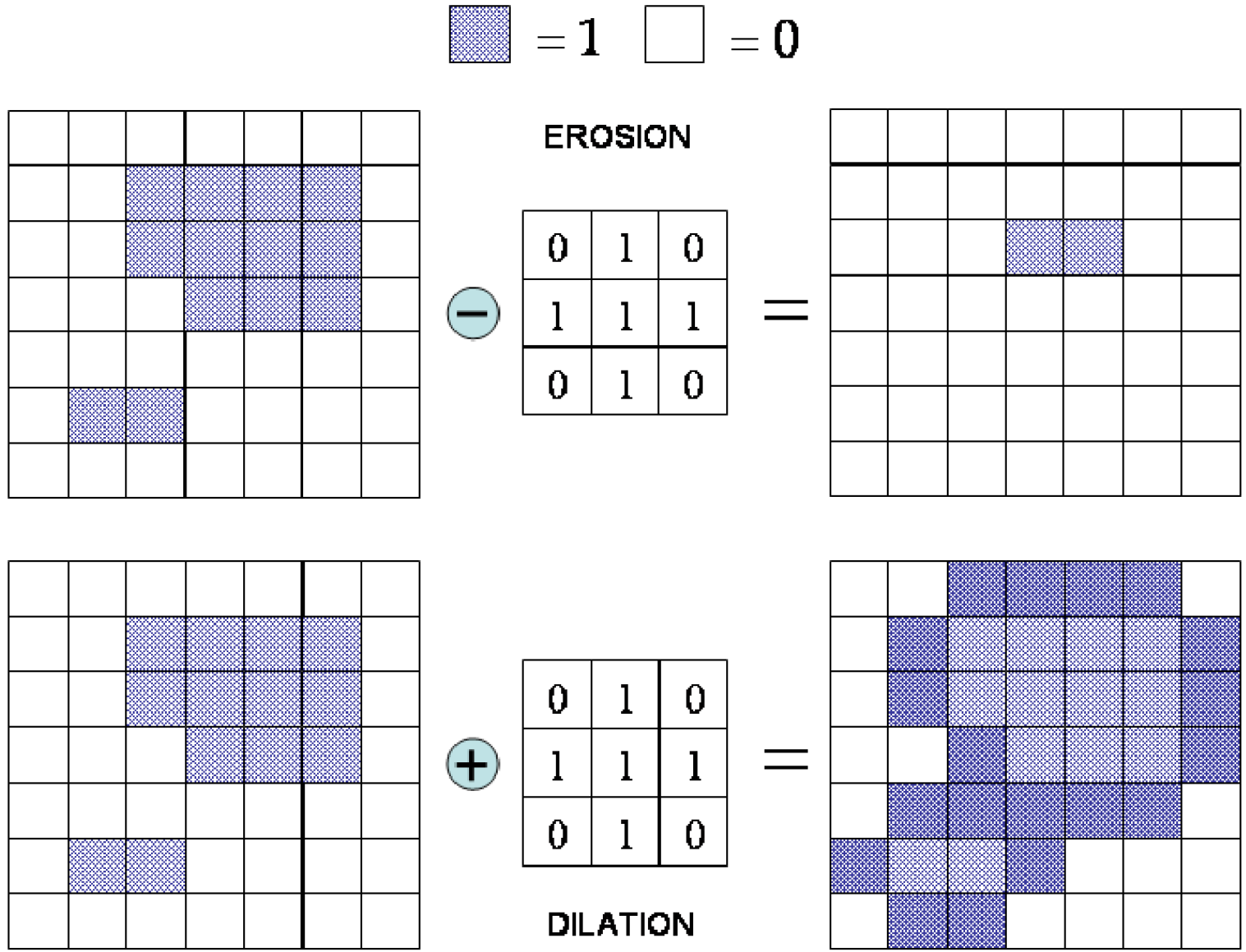
Morphological operations

- In BW images, a morphological operation outputs a modified BW image.
- Through a morphological operation, we decide which pixels remain foreground and which remain background.
- Essential to a morphological operation is the **structuring element**.
- In Matlab, the coordinates of the structuring element centre pixel are defined by the expression floor((size (nhood) þ 1)/2), where nhood is the structuring element.



Dilation and erosion

- To perform **erosion** of a binary image, we successively place the centre pixel of the structuring element on each foreground pixel (value 1). If any of the neighbourhood pixels are background pixels (value 0), then the foreground pixel is switched to background.
- To perform **dilation** of a binary image, we successively place the centre pixel of the structuring element on each background pixel. If any of the neighbourhood pixels are foreground pixels (value 1), then the background pixel is switched to foreground.
- Opening : erosion followed by dilation
- Closing: dilation followed by erosion


= 1
= 0
EROSION
0 1 0
1 1 1
0 1 0
DILATION
0 1 0
1 1 1
0 1 0

Application

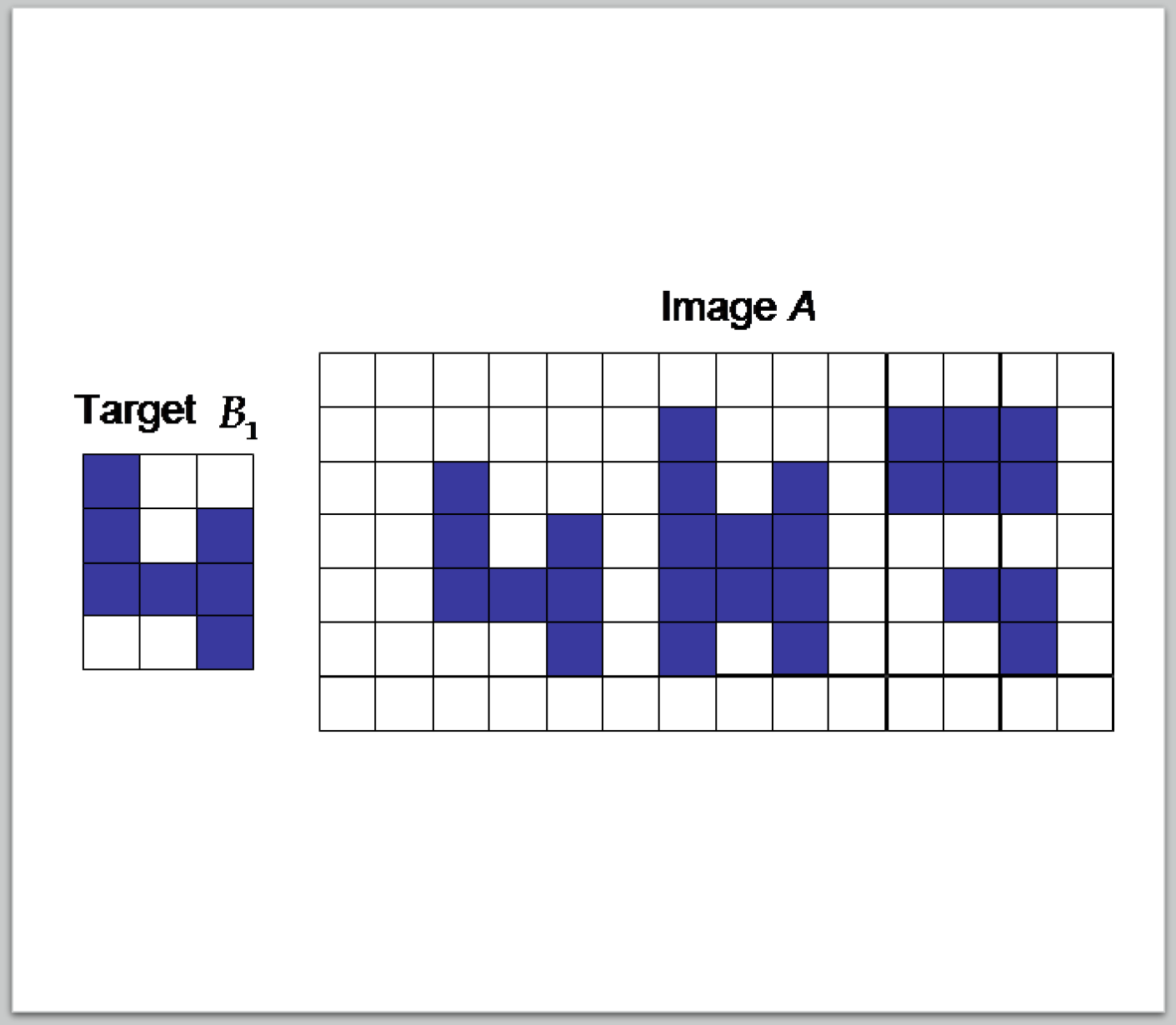
- Erosion
  - Removes small isolated features,
  - Breaks apart thin, joining regions in a feature
  - Reduces the size of solid objects by ‘eroding’ them at the boundaries.

- Dilation
  - Broadens and thickening narrow regions
  - Grows a feature around its edges.

- Matlab functions: imerode, imdilate

Hit-or-miss transformation

- A basic tool for shape detection.
- The pattern is characterized by a structuring element.
- Searching for the locations inside the image of the correct combination of foreground and background pixels.
- Applications: finding fiducial and calibration target in an image, QR code detection, barcode detection



Step 1: erosion with the target → Hits

Target B_1

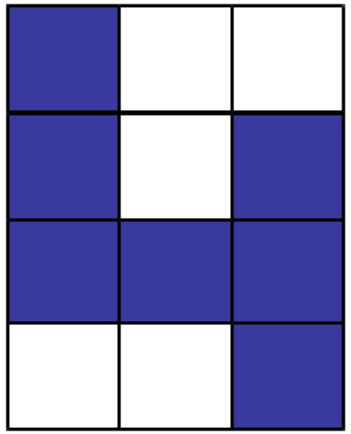
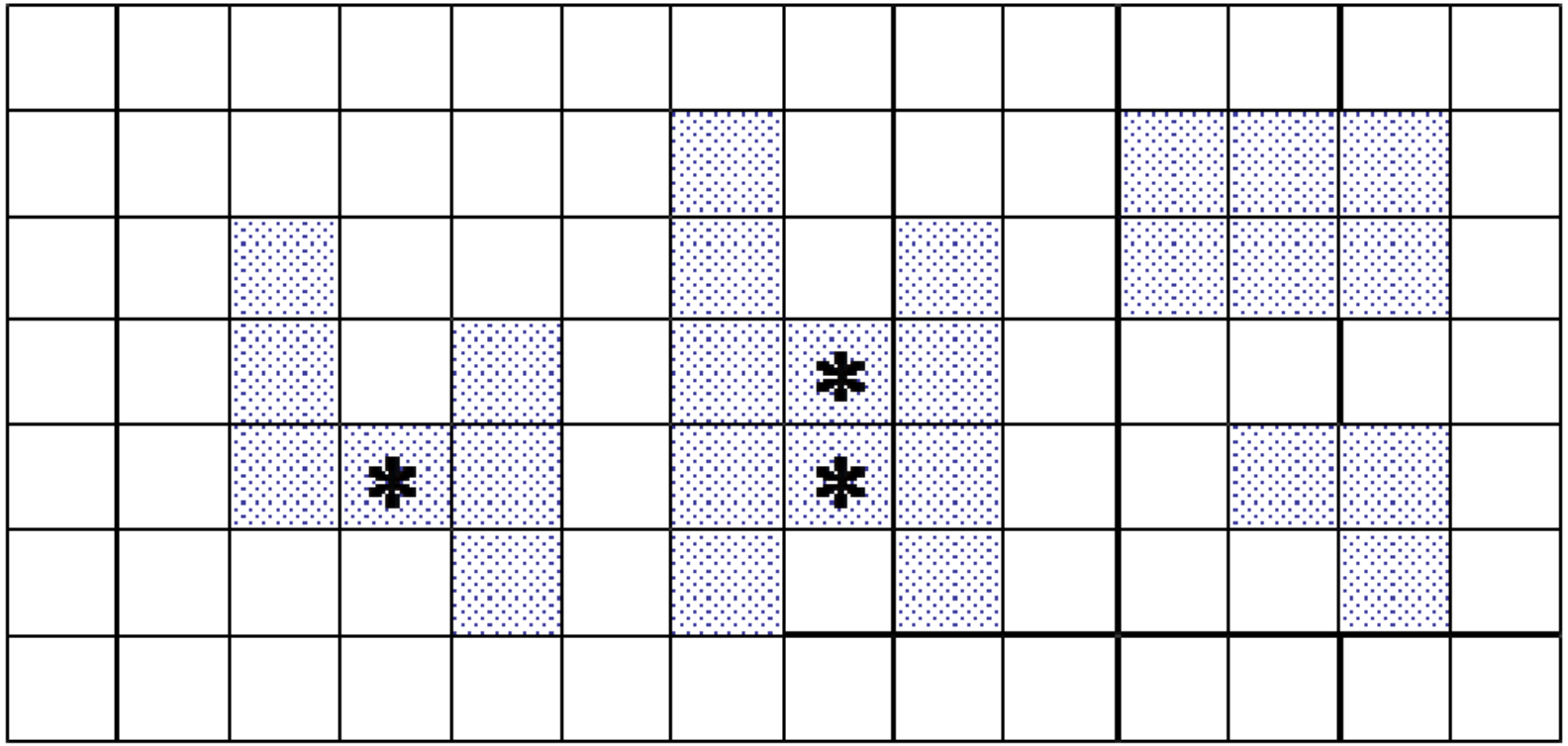


Image $A \ominus B_1$



Step 2: erosion with the complement structuring element and complement image→Misses

Target $\bar{B}_1$

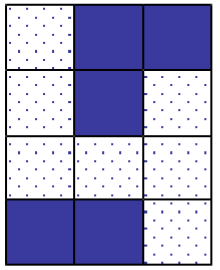
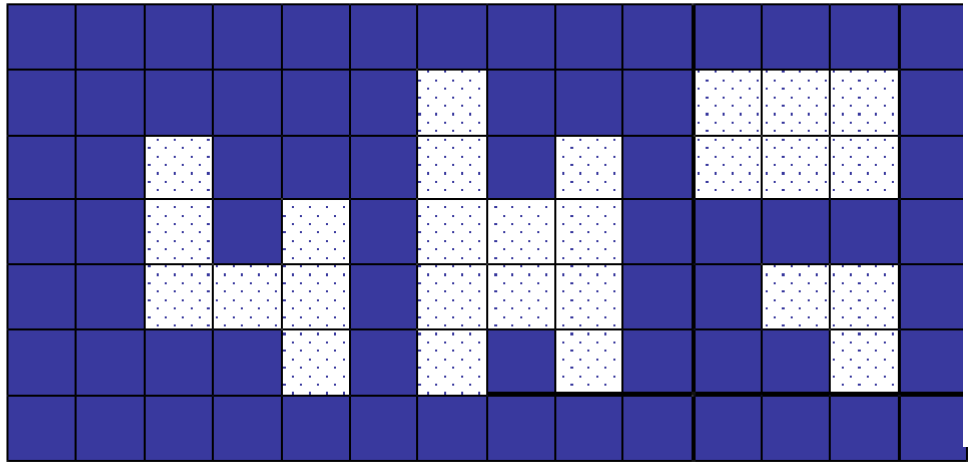


Image $\bar{A}$



Target $\bar{B}_1$

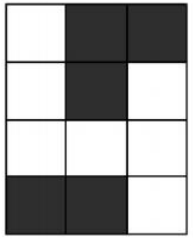
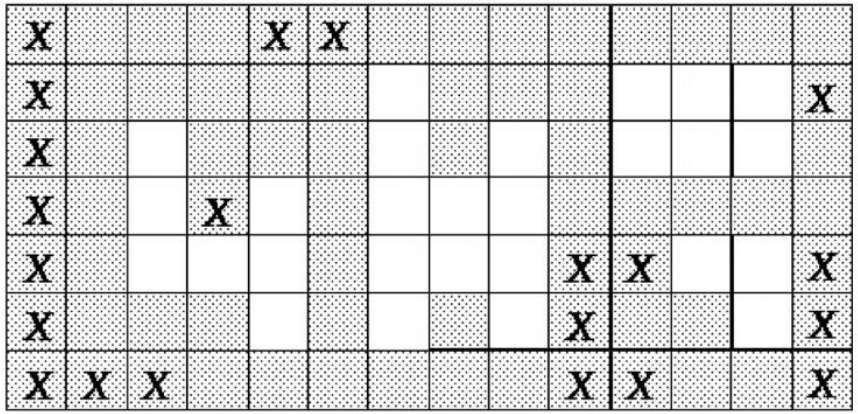
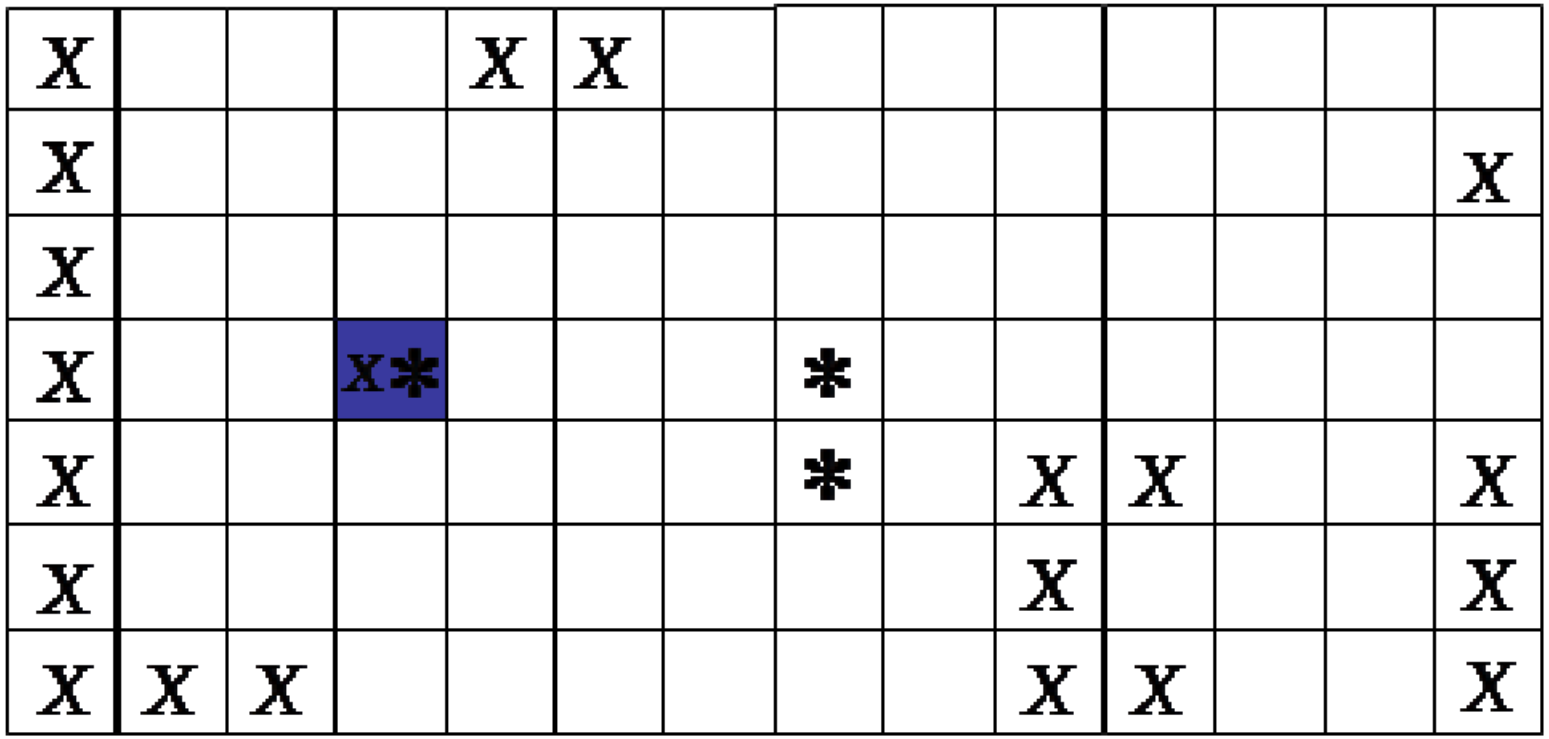


Image $\bar{A} \ominus \bar{B}_1$



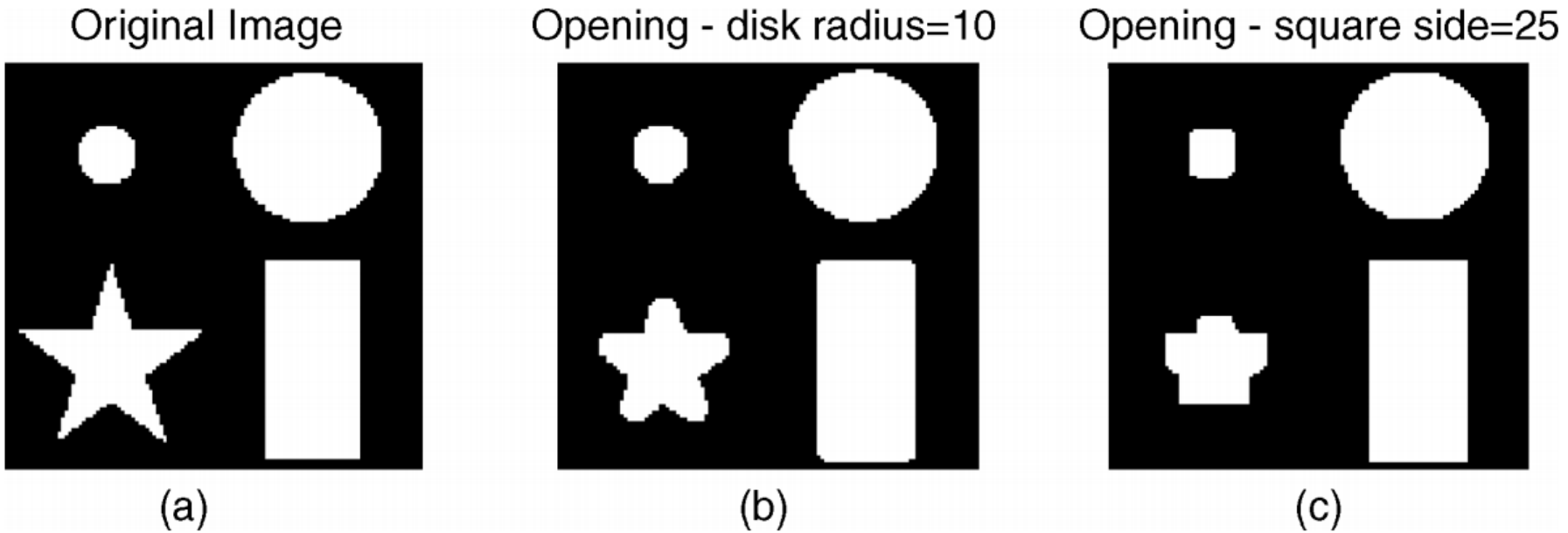
Step 3: Intersection of hits and misses

Image $(A \ominus B_1) \cap (\bar{A} \ominus \bar{B}_1)$



Opening by reconstruction

- A method to fully recover the effects of opening operation.
- Requires two images: the original binary image (the mask) and the marker (the image obtained after the initial step of erosion).
- Mask constrains the marker, never allowing new foreground pixels to appear.
- Exercise 2 in the lab



References

- Many pictures from this presentation were taken from the book “Fundamentals of digital image processing” by Chris Solomon & Toby Breckon