MCDB/BCHM 4312 & 5312 – Quantitative Optical Imaging

Lecture 18:

Bradley's method and morphological operations

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Learning objectives

- Adaptive threshold algorithm using Bradley's method
- Morphological operations:
  - Dilation and Erosion
  - Closing and Opening

How to deal with uneven illumination?

Using an adaptive thresholding algorithm

- `imbinarize` can implement a different algorithm called Bradley's method

- Bradley's method uses adaptive thresholding – different thresholds are computed for each pixel in the image

- Each pixel is compared to the mean value of its neighbors. If it is *t* percent brighter, then the corresponding mask pixel is true.

Link to article

MATLAB implementation

- Read in the image rice.png

- Apply Bradley's method using

```
mask = imbinarize(I, 'adaptive')
```

Comparison of Otsu's vs Bradley's method

Otsu's method

Bradley's method

Questions?

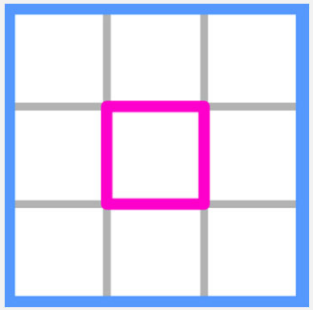
Automated binarization algorithms tend to have artifacts that change the shape of the object

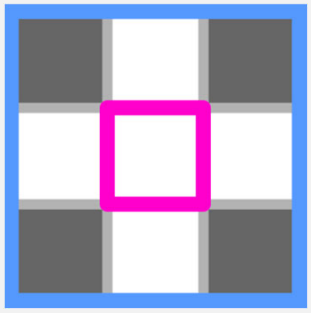
Morphological operations

- Morphological operations are image processing operations that process images based on shapes (morphology)

- Basic principle is to probe an image with a simple shape (e.g., a square or a circle) and define if the shape fits or misses shapes in the image

The structuring element





A **structuring element** is a small logical array containing a **shape** used to probe the image

The **center (or origin)** of the structuring element is the pixel that is being probed

The **shape** is defined by `true` pixels

Use `strel` to generate structuring elements

Examples:

- `SE = strel('square', width)`
- `SE = strel('disk', radius)`
- `SE = strel('line', length, angle)`

Look at documentation for all options

Note: You can also use a logical matrix as a structuring element

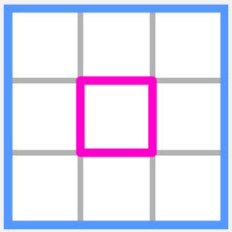
The output of `strel` is a structured array `struct`

- The mask that defines the structuring element is in the field `Neighborhood`

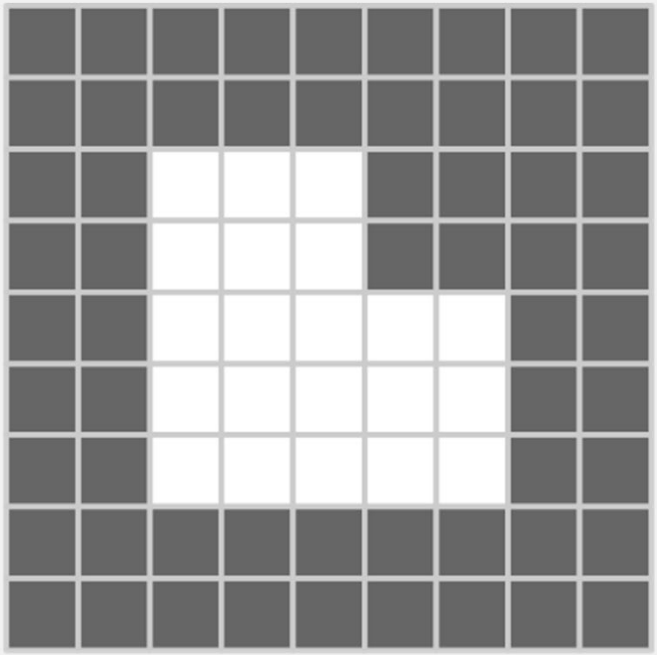
- You can (and should) plot this to see what the structuring element looks like

```
>> imshow(SE.Neighborhood)
```

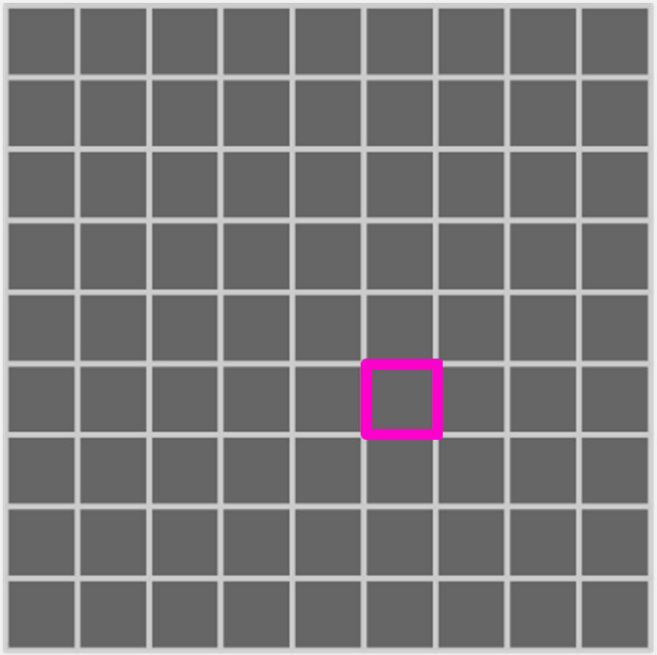
Basic morphological operation



Structuring element



Input mask



Output mask
(partially complete operation)

Morphological operations

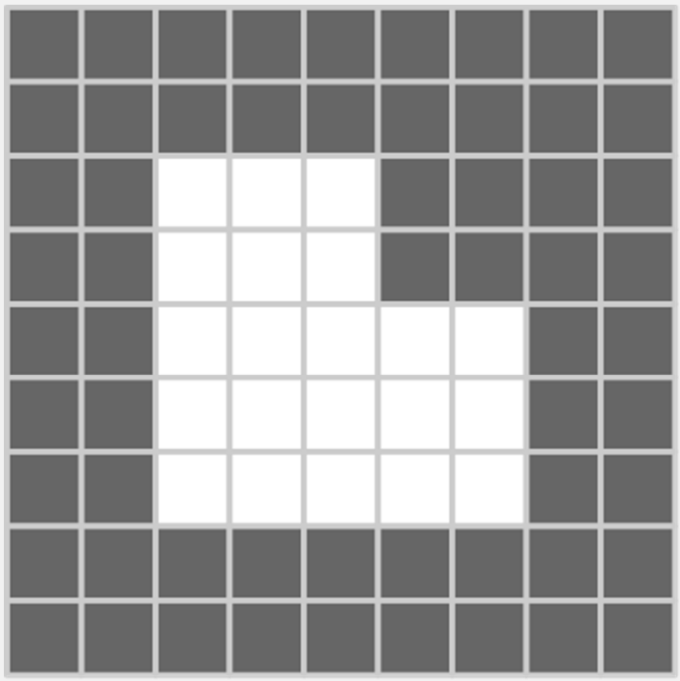
- The basic morphological operations are erosion and dilation
- Erosion tends to remove pixels from a mask
- Dilation tends to add pixels to a mask

Morphological Erosion

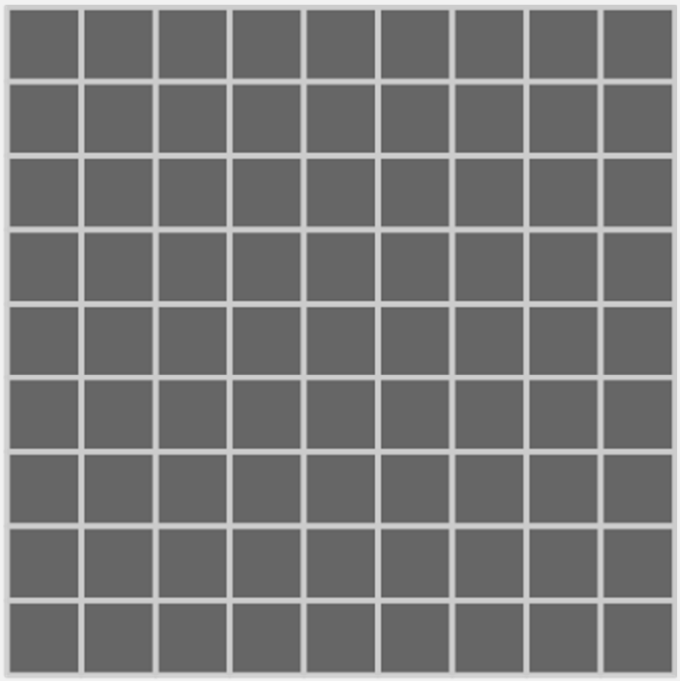
If **every** true pixel in the structuring element is over a true pixel in the image, then the **output is true**

Ignore any pixels in the structuring element that does not fit the image

Algorithm of morphological operations

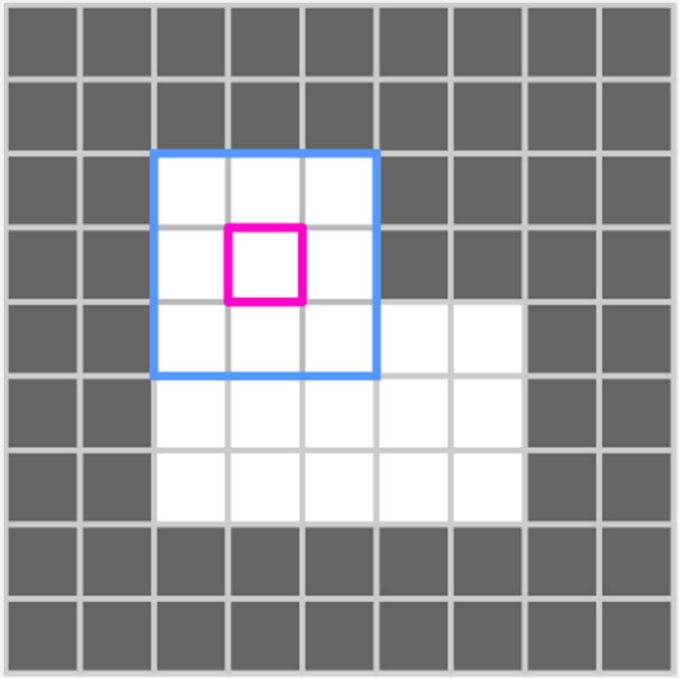


Input mask

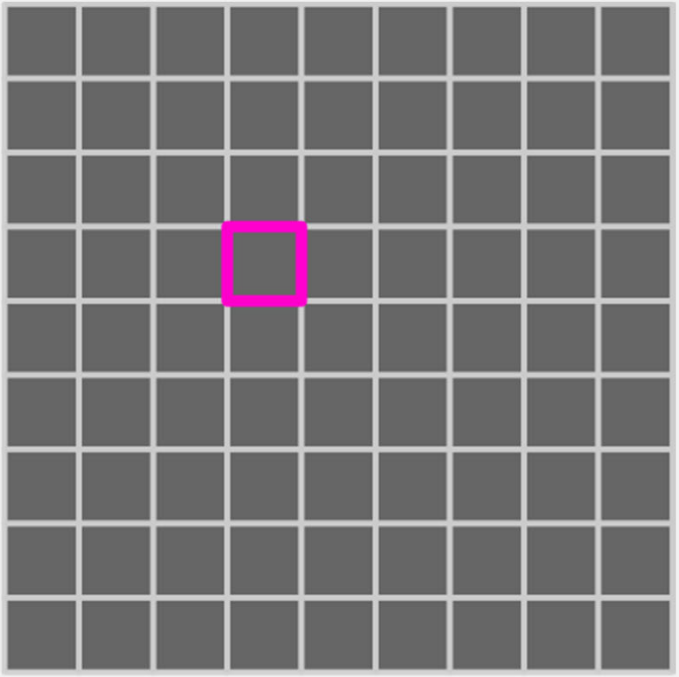


Output mask

Place structuring element over a pixel

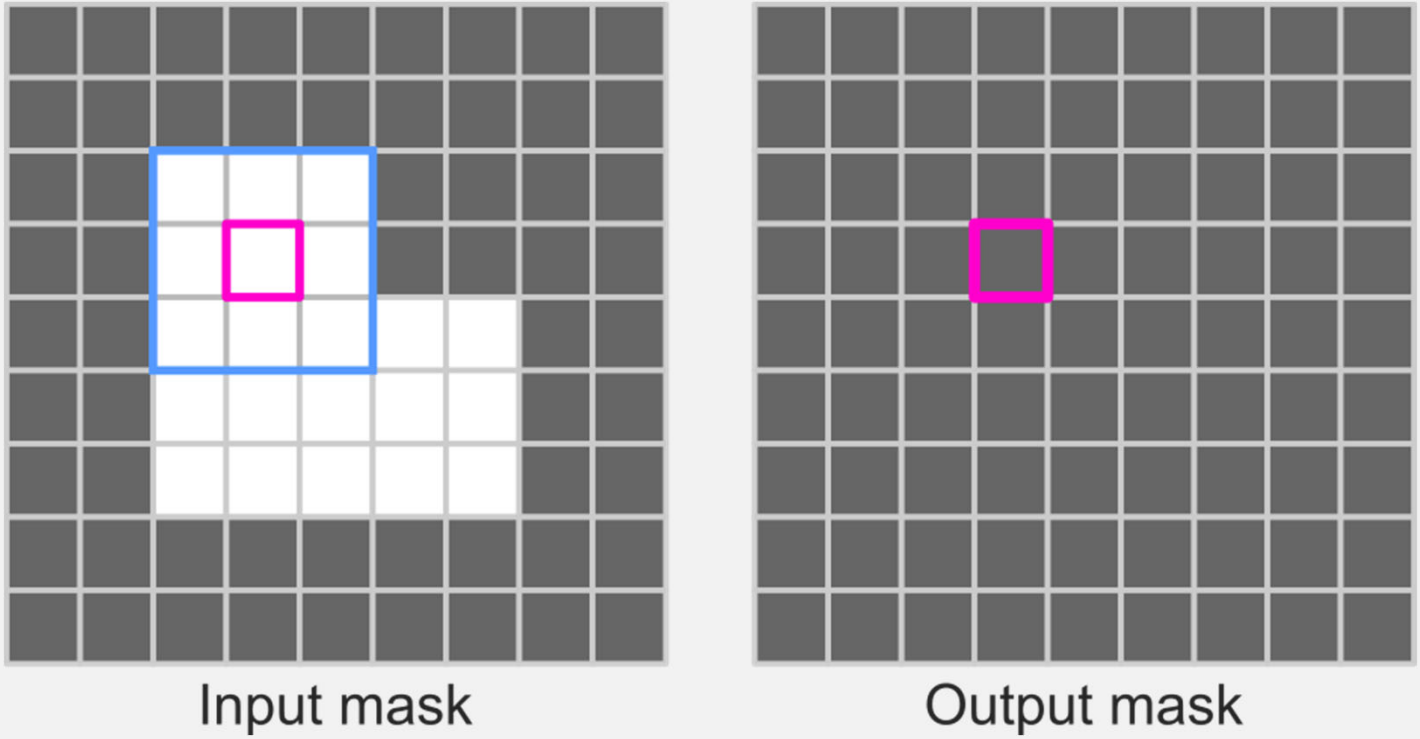


Input mask

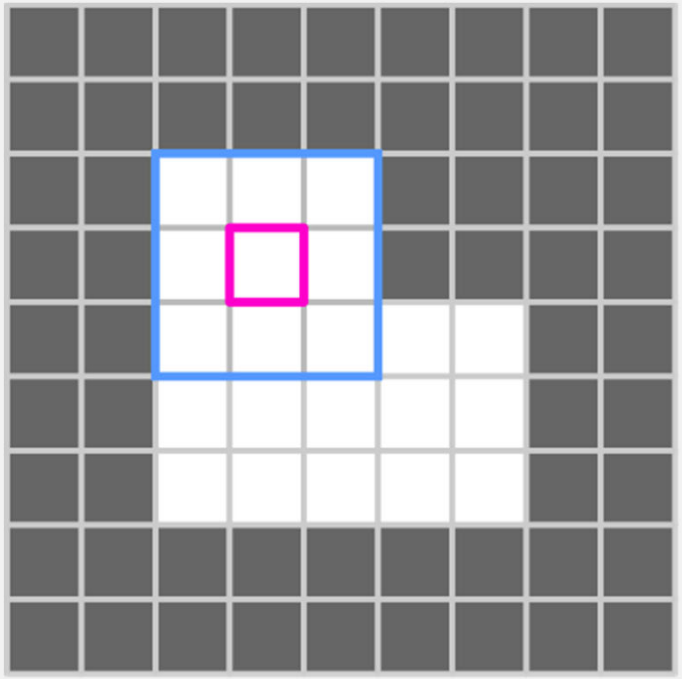


Output mask

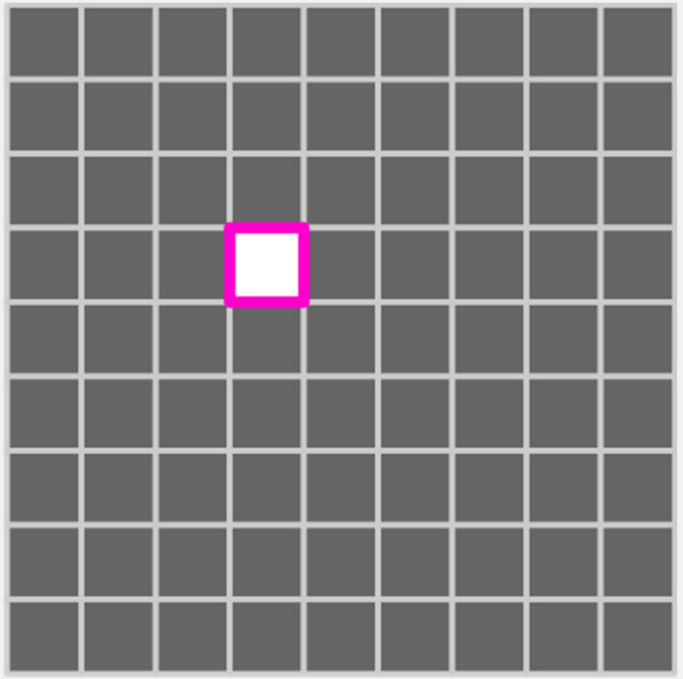
Perform comparison – is every true pixel in the structuring element on top of a true pixel in the image?



Update the output mask based on comparison

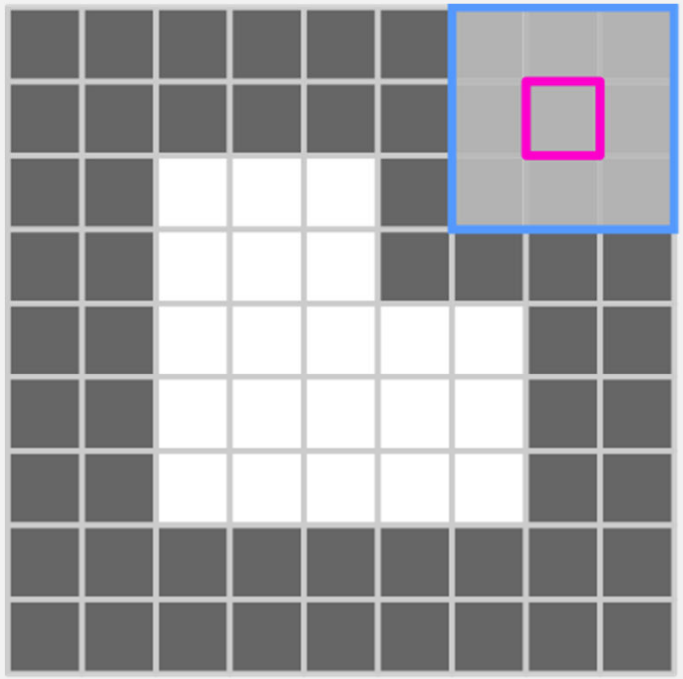


Input mask

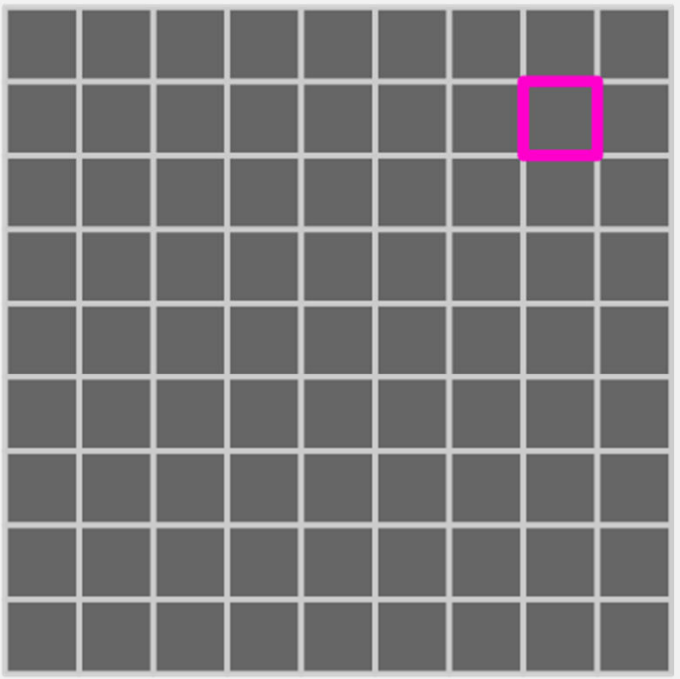


Output mask

What is the output for this pixel?

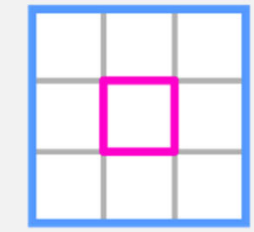


Input mask

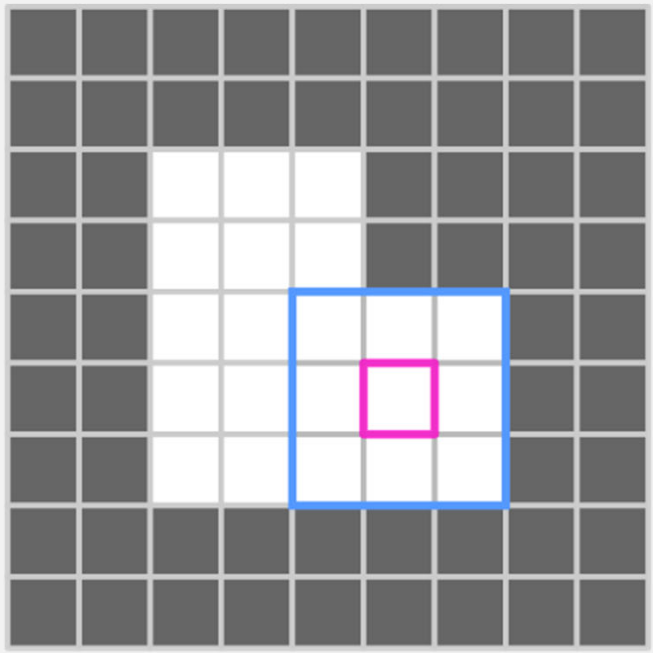


Output mask

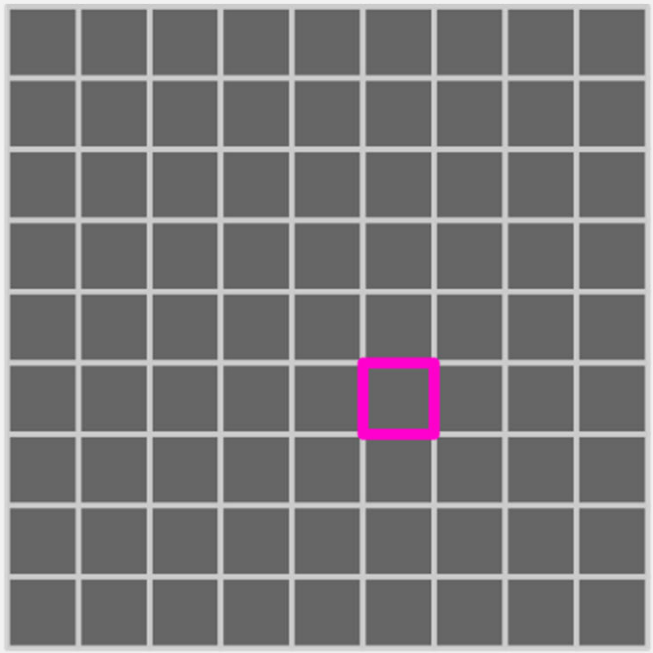
What is the value of the output pixel (true/false)?



Structuring element

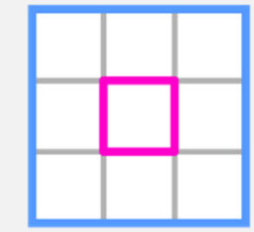


Input mask

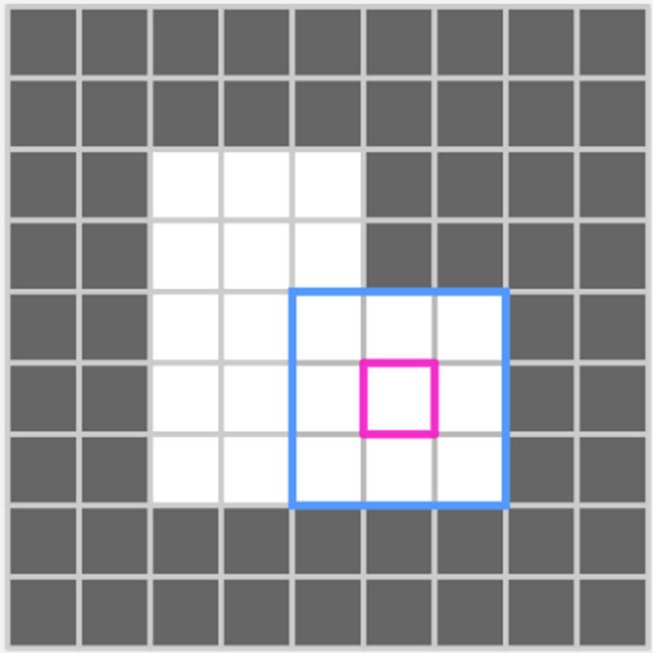


Output mask
(partially complete operation)

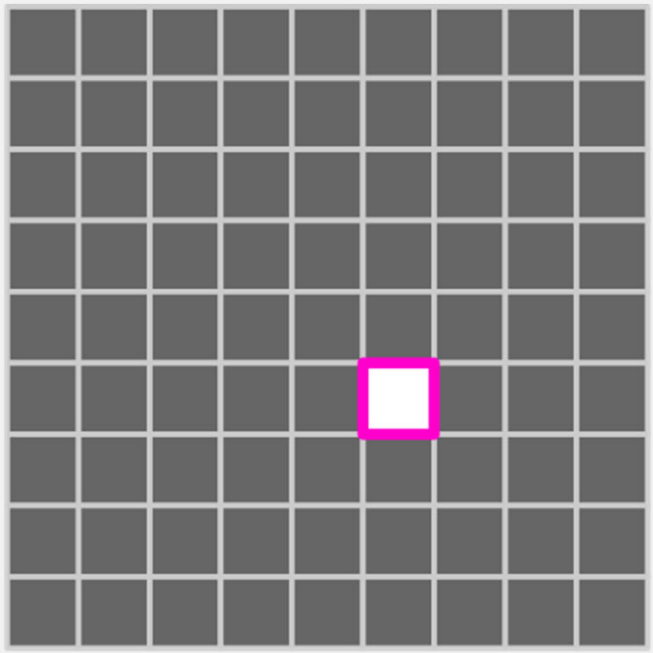
What is the value of the output pixel (true/false)?



Structuring element

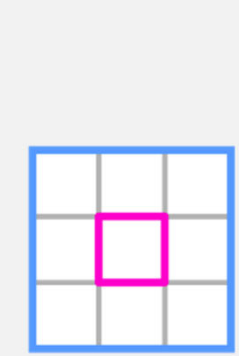


Input mask

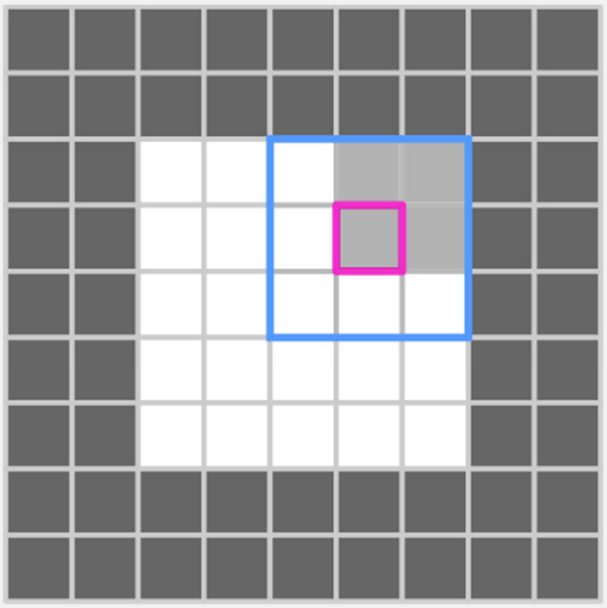


Output mask
(partially complete operation)

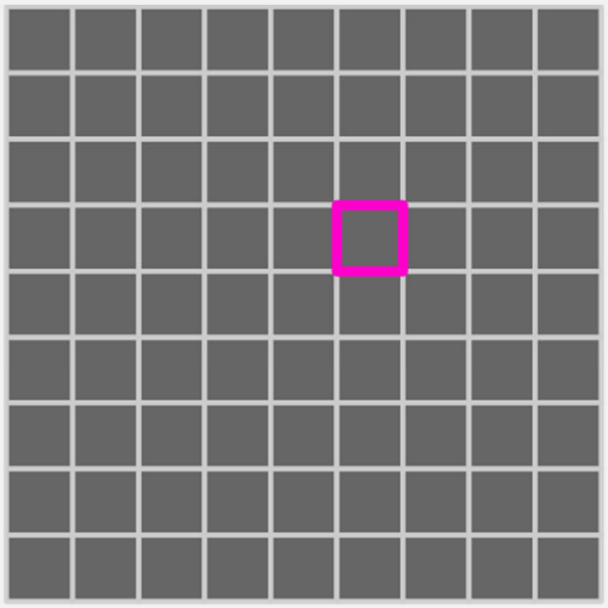
What is the value of the output pixel (true/false)?



Structuring element

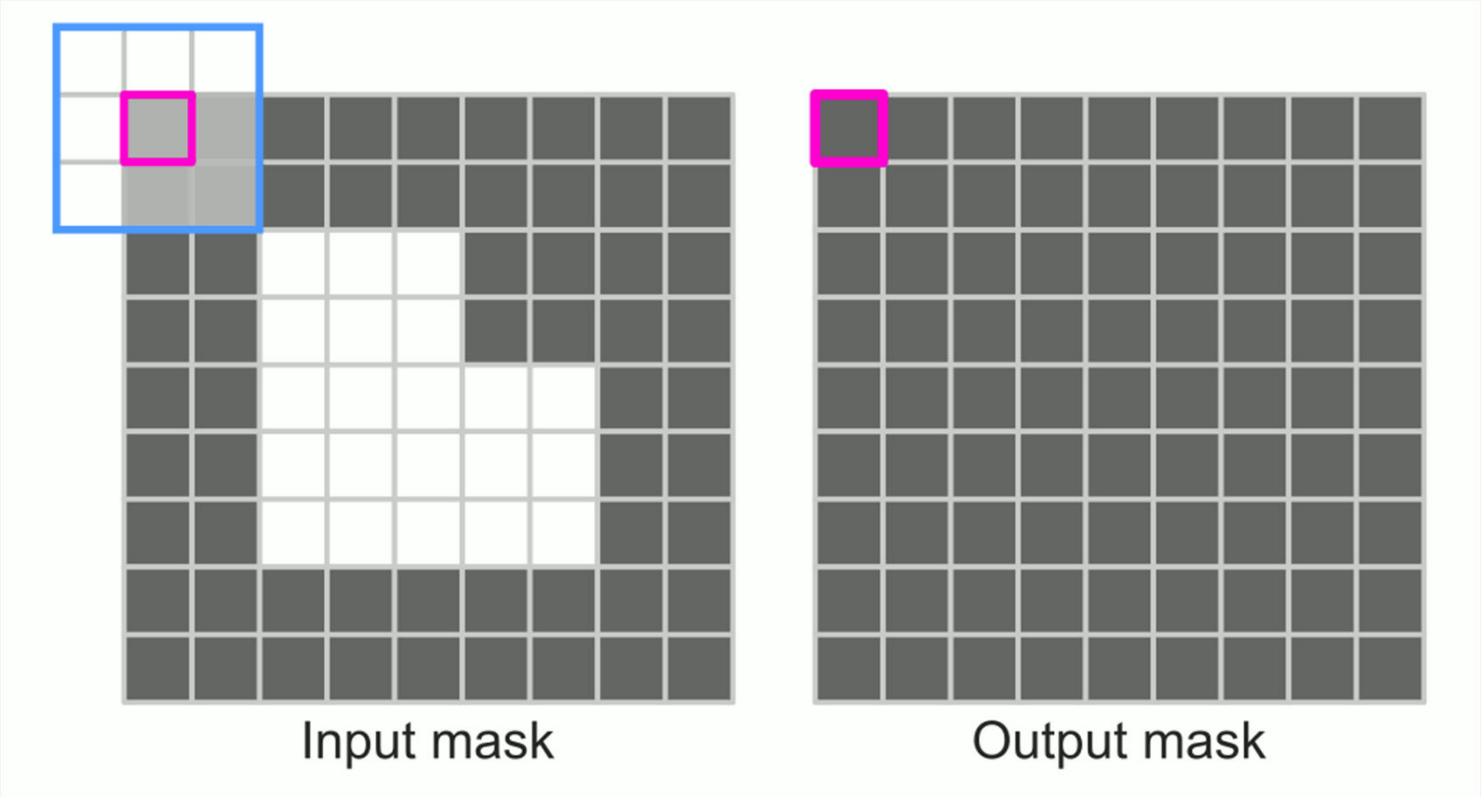


Input mask

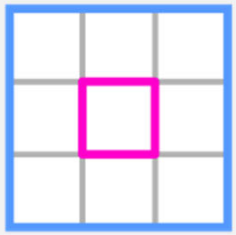


Output mask
(partially complete operation)

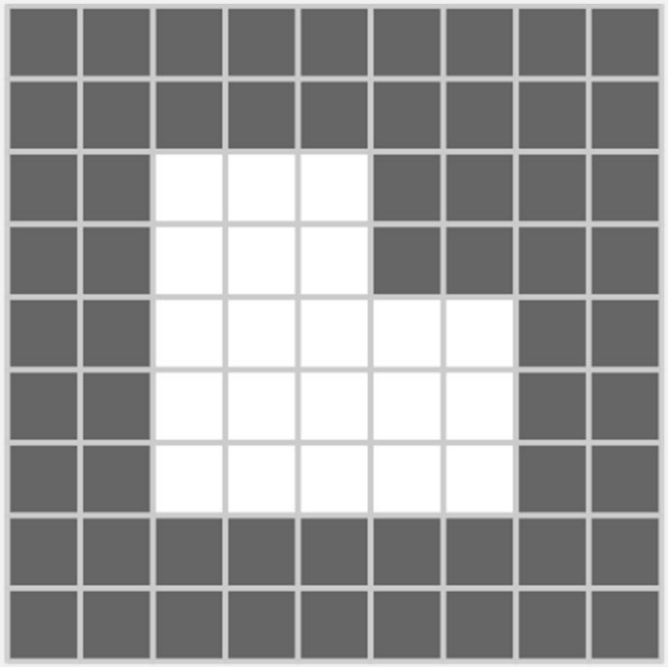
Repeat over every pixel



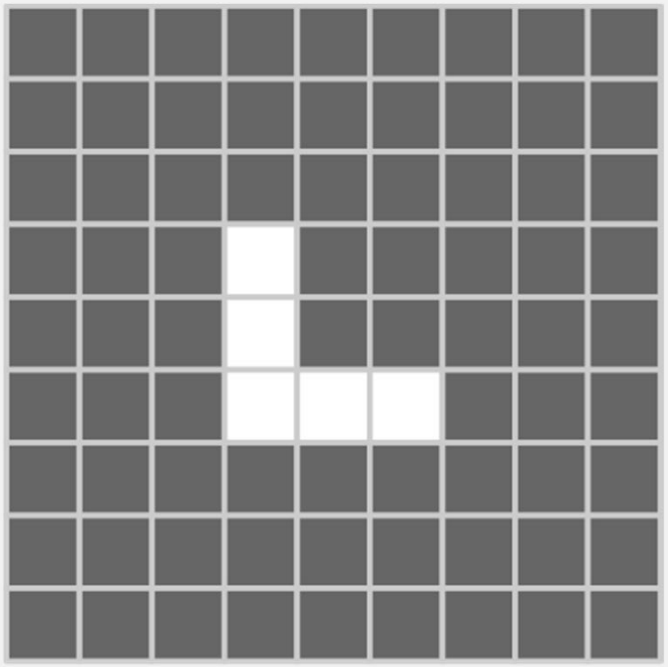
Output of erosion



Structuring element

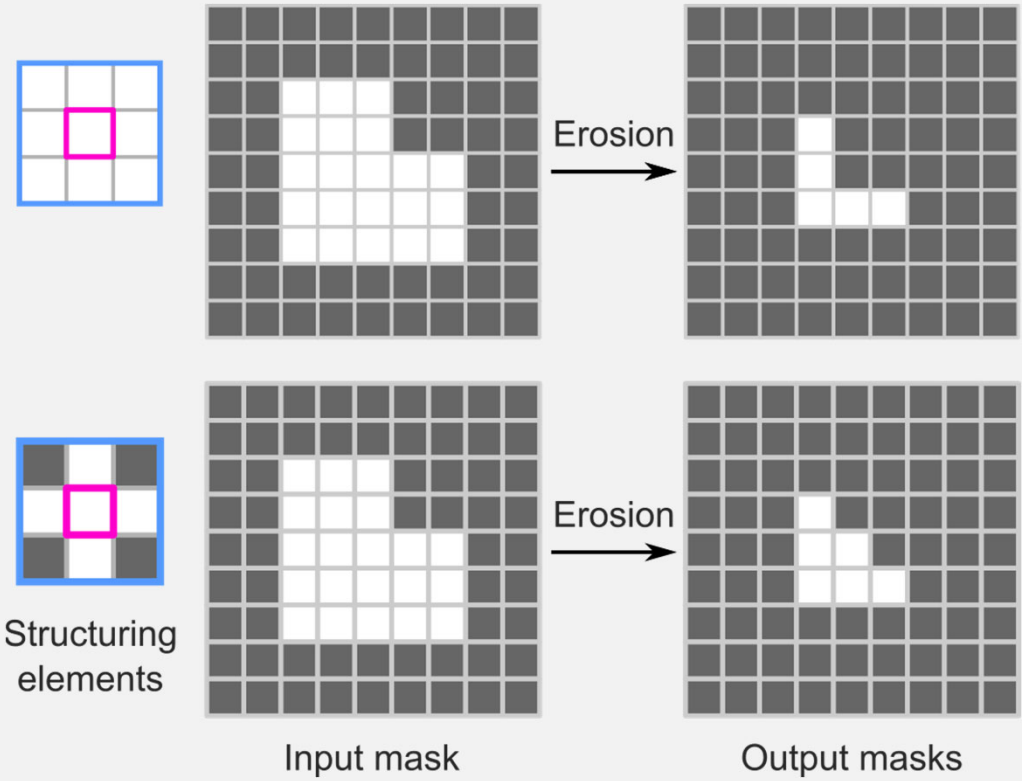


Input mask



Output mask

Shape and size of structuring element affects final shape and size



Questions?

MATLAB implementation - `imerode`

```
M = imerode(BW, SE)
```

- Inputs:
  - `BW` = logical array (mask)
  - `SE` = structuring element

Use `strel` to generate structuring elements

Examples:

- `SE = strel('square', width)`
- `SE = strel('disk', radius)`
- `SE = strel('line', length, angle)`

Look at documentation for all options

Note: You can also use a logical matrix as a structuring element

Practice

- Read in the image `blobs.png`
- Erode the image with a 3x3 square structuring element

```
M = imerode(BW, SE)

SE = strel('square', width)
```

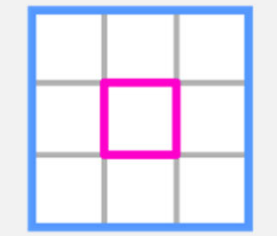
When to use erosion?

- When you want to reduce the size of objects in your mask but preserve overall shape

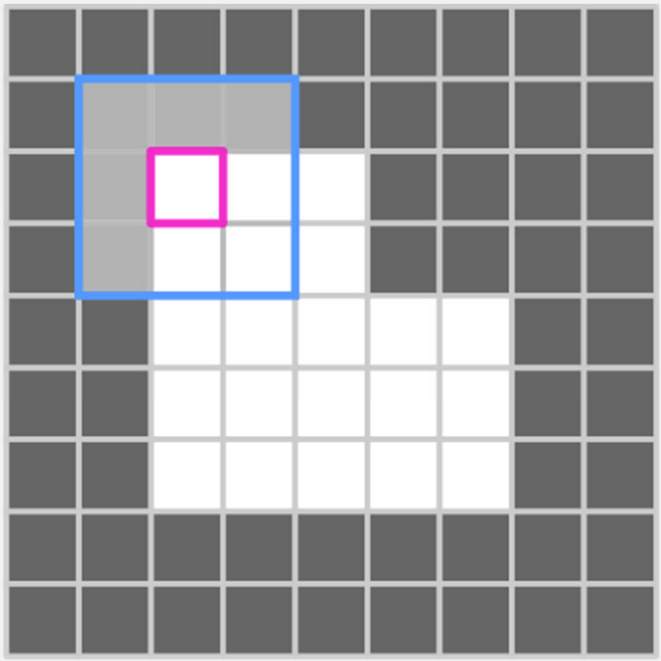
Morphological Dilation

If **any** true pixel in the structuring element is over a true pixel in the image, then the **output is true**

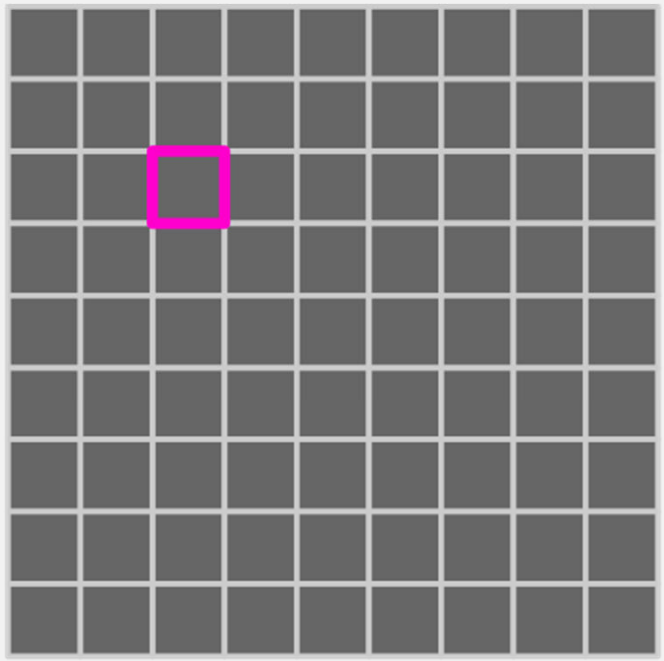
What is the value of the output pixel (true/false)?



Structuring element

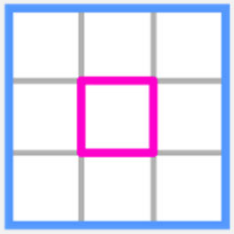


Input mask

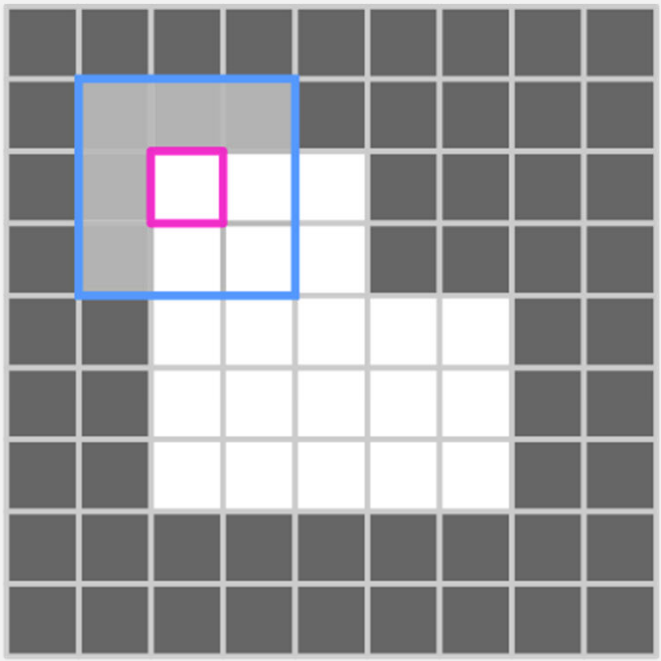


Output mask
(partially complete operation)

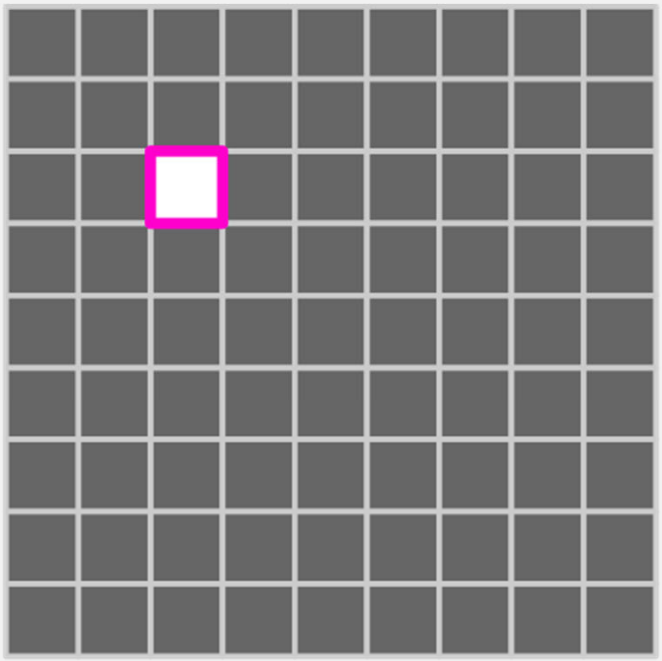
What is the value of the output pixel (true/false)?



Structuring element

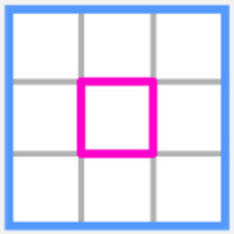


Input mask

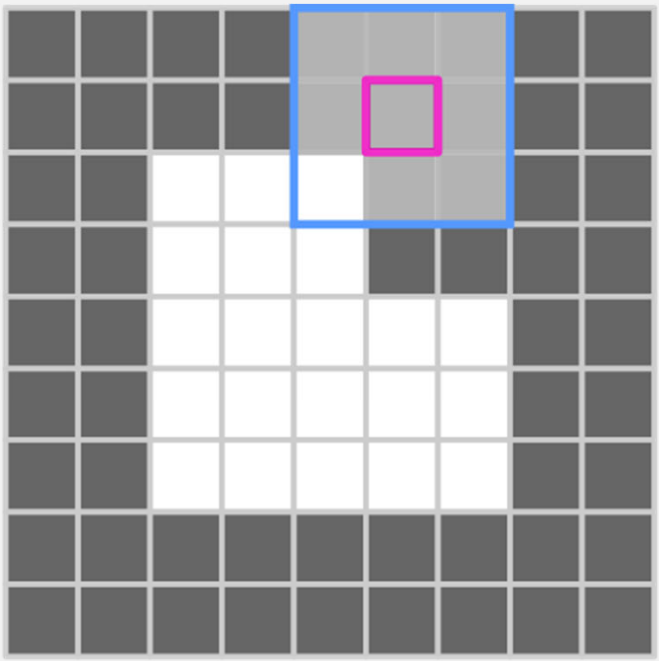


Output mask
(partially complete operation)

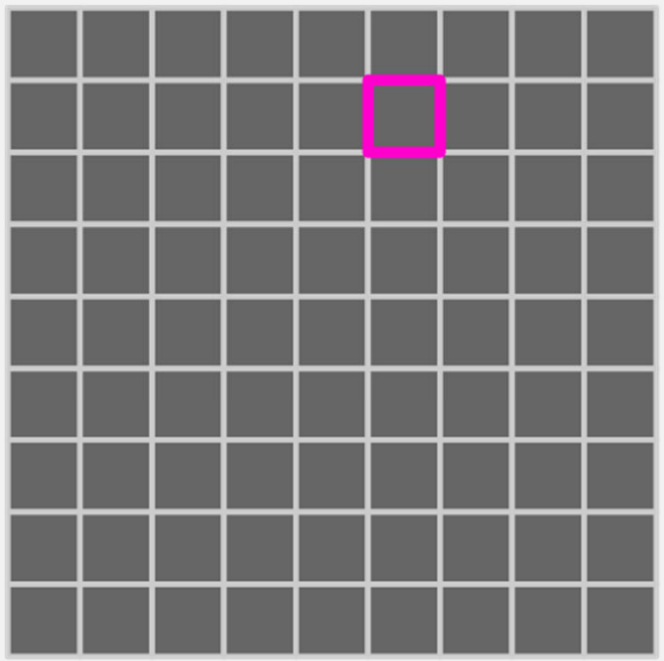
What is the value of the output pixel (true/false)?



Structuring element

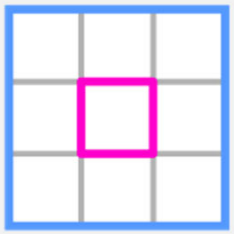


Input mask

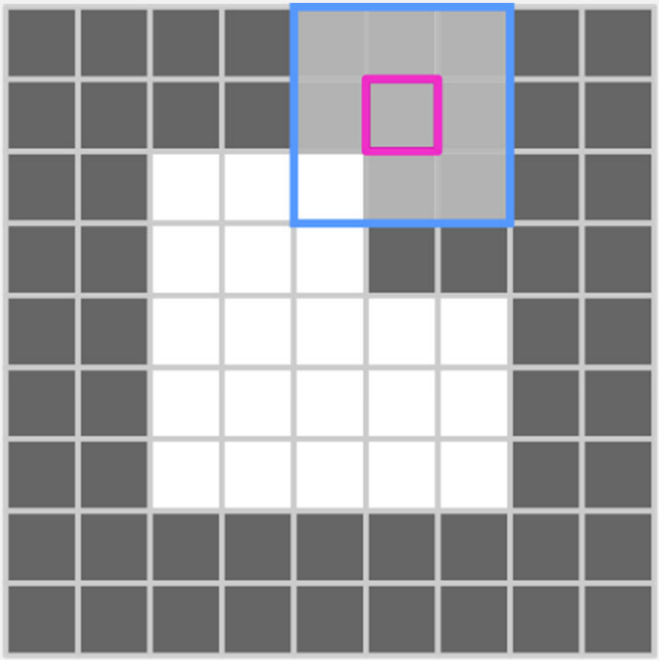


Output mask
(partially complete operation)

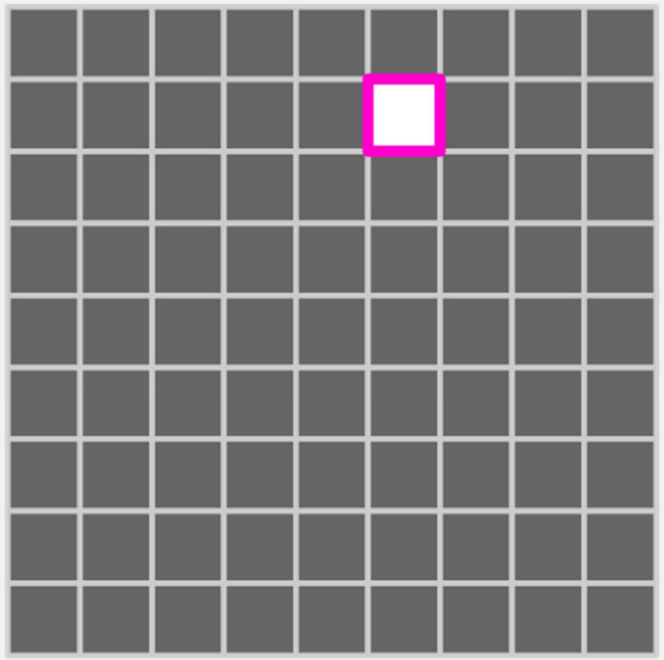
What is the value of the output pixel (true/false)?



Structuring element

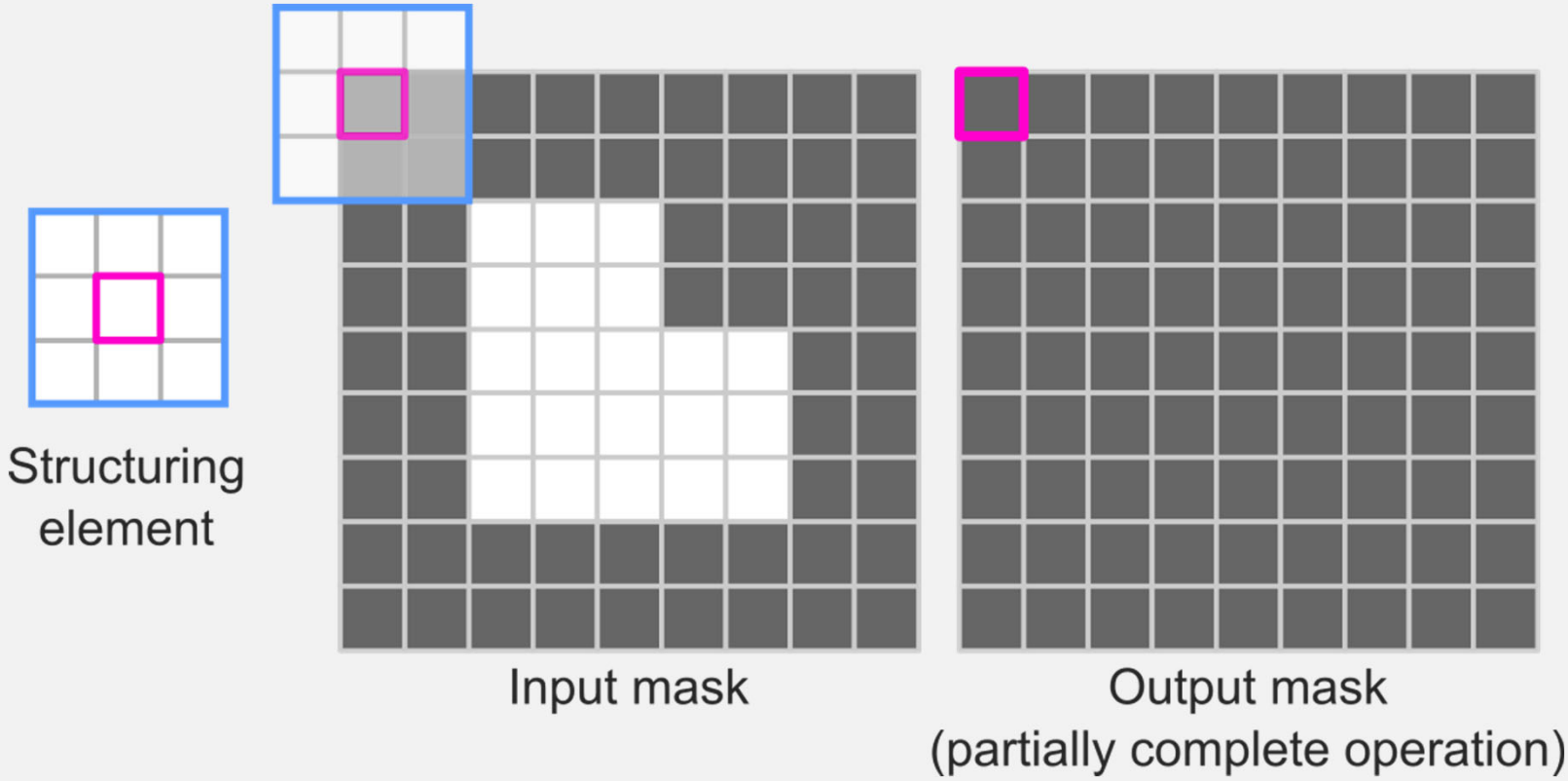


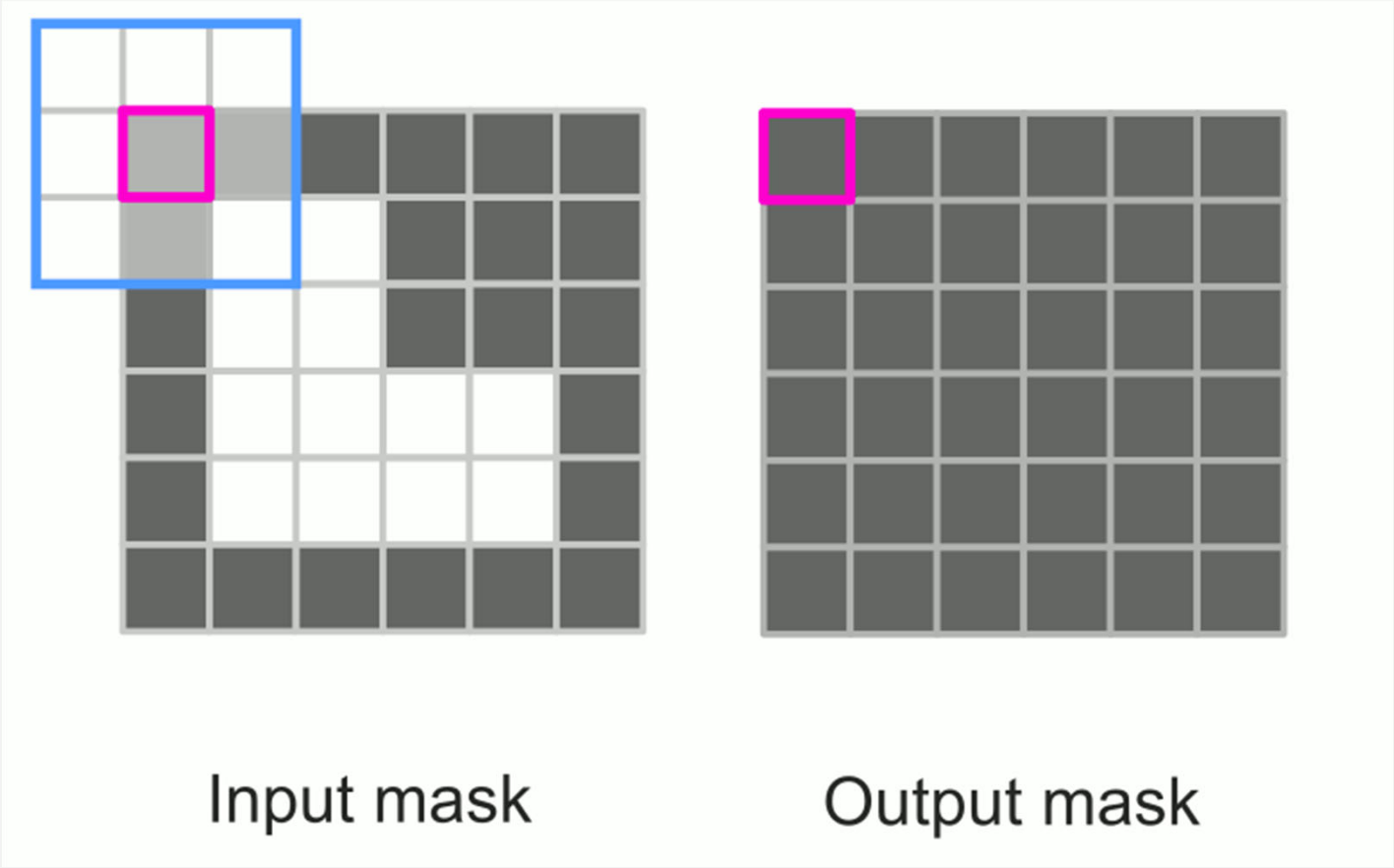
Input mask



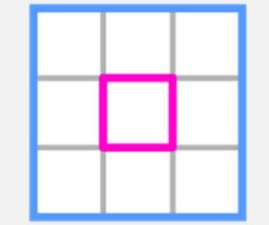
Output mask
(partially complete operation)

What is the value of the output pixel (true/false)?

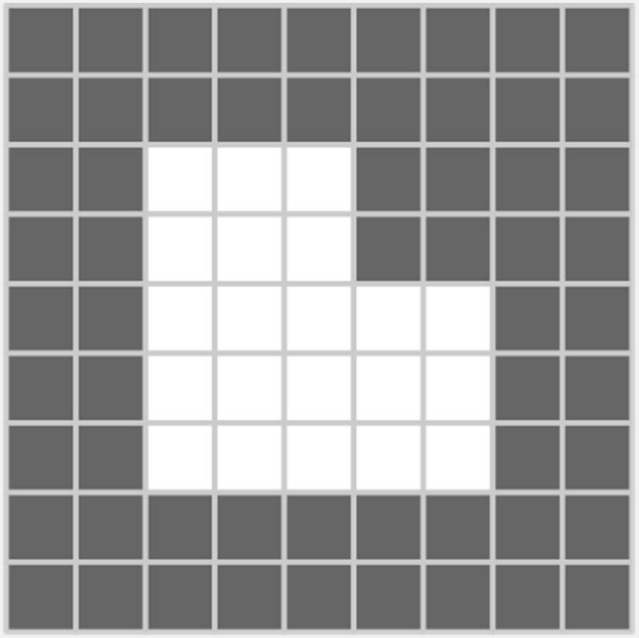



Input mask
Output mask

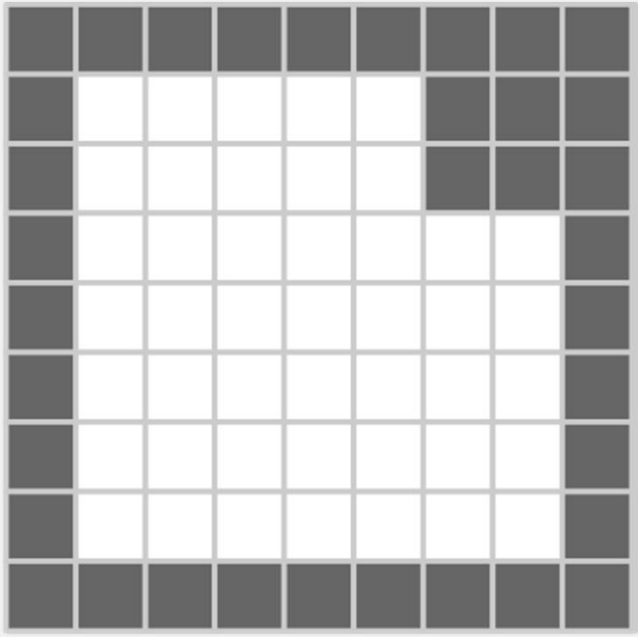
Output of morphological dilation



Structuring element



Input mask



Output mask

```
M = imdilate(BW, SE)
```

BW = logical array (mask)

SE = structuring element

Task

- Read in the image 'blobs.png'
- Dilate the image with a disk structuring element, radius of 4

```
M = imdilate(BW, SE)

SE = strel('disk', radius)
```

When to use dilation?

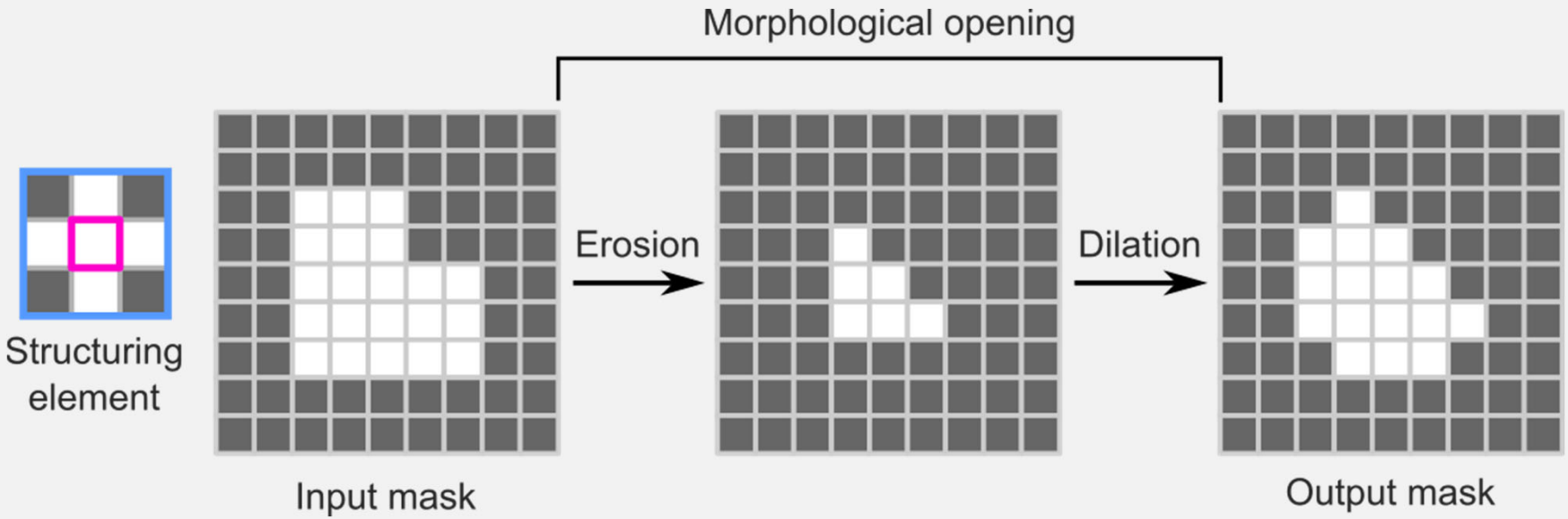
- If you want to grow your mask by a few pixels but keep the shape the same

Questions?

Compound morphological operations

- Opening and closing are compound morphological operations because they use the erosion and dilation operations
- Opening is erosion followed by dilation
- Closing is dilation followed by erosion

Opening is erosion followed by dilation



```
M = imopen(BW, SE)
```

BW = Input mask

SE = Structuring element

Practice

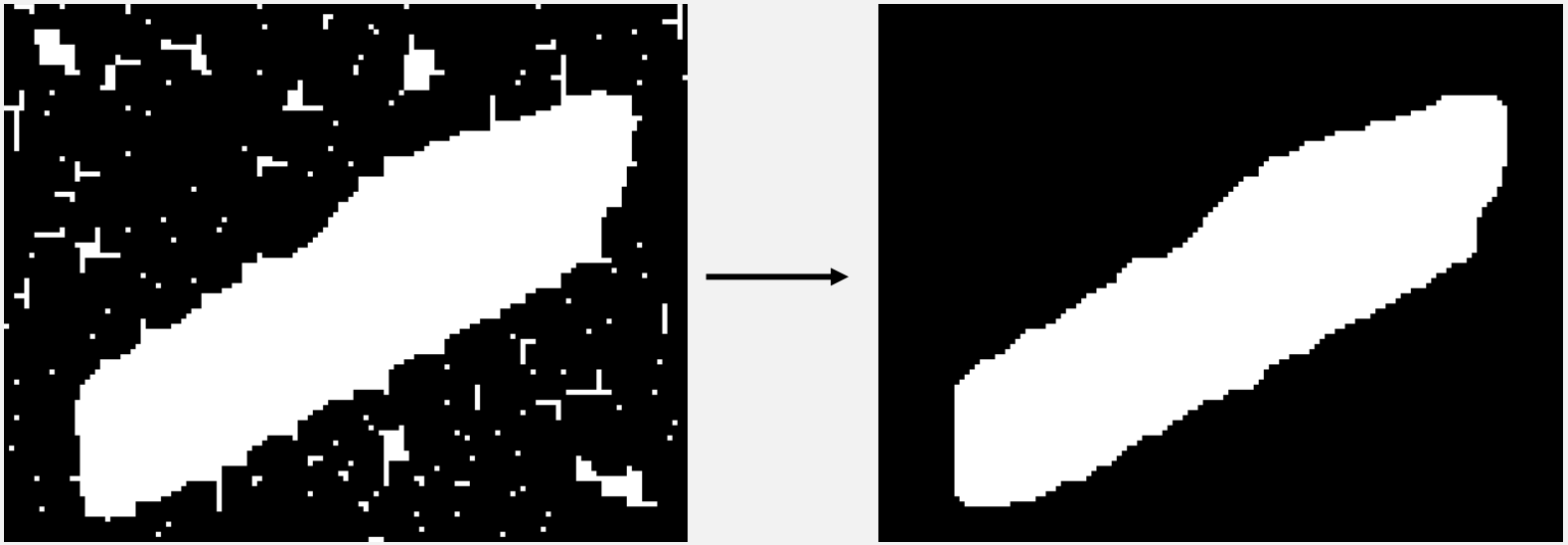
- Read in the image 'blobs.png'
- Open the image with a line structuring element, length of 5, angle 0 (horizontal line)

```
M = imopen(BW, SE)

SE = strel('line', length, angle)
```

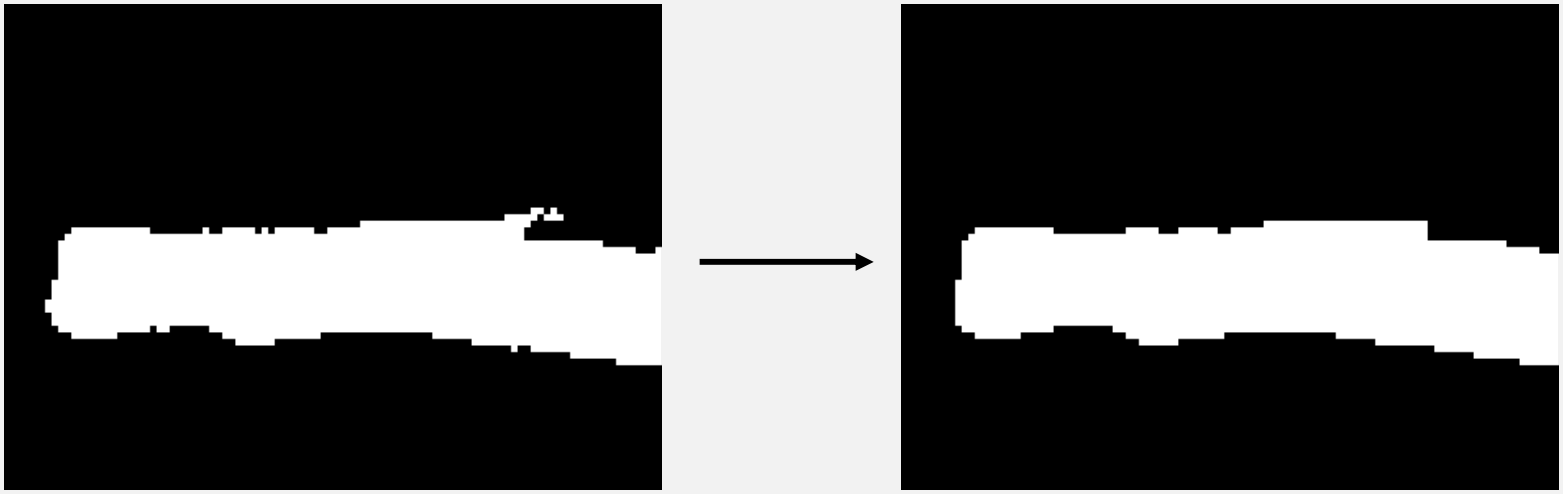
Why use opening?

- Morphological opening removes foreground objects smaller than the structuring element



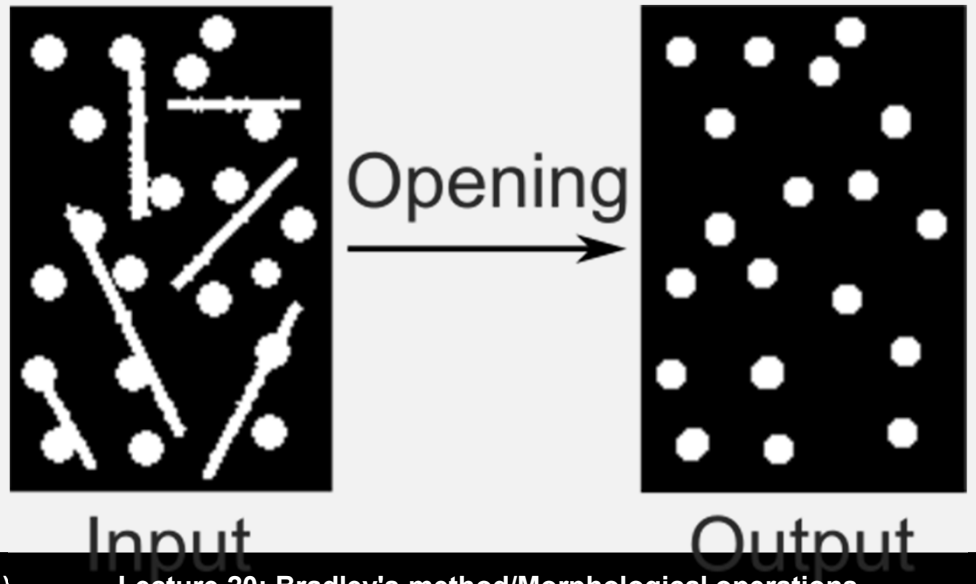
Why use opening?

- Morphological opening is useful for smoothing the edges of segmented objects

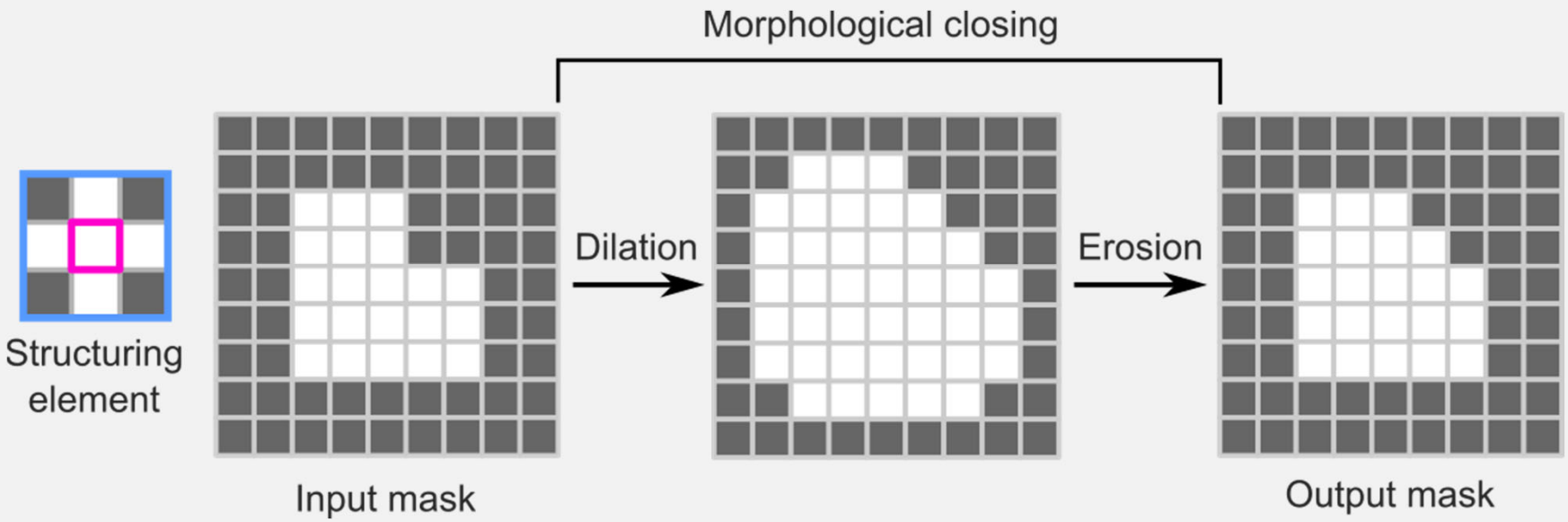


Why use opening?

- Morphological opening is useful for removing objects with a specific shape from an image



Closing is dilation followed by erosion



```
M = imclose(BW, SE)
```

BW = Input mask

SE = Structuring element

Task

- Read in the image 'blobs.png'
- Close the image with a square structuring element, width of 10

```
M = imclose(BW, SE)

SE = strel('square', width)
```

Why use closing?

- Morphological closing **fills in holes smaller than the structuring element**, while preserving the shape and size of other objects