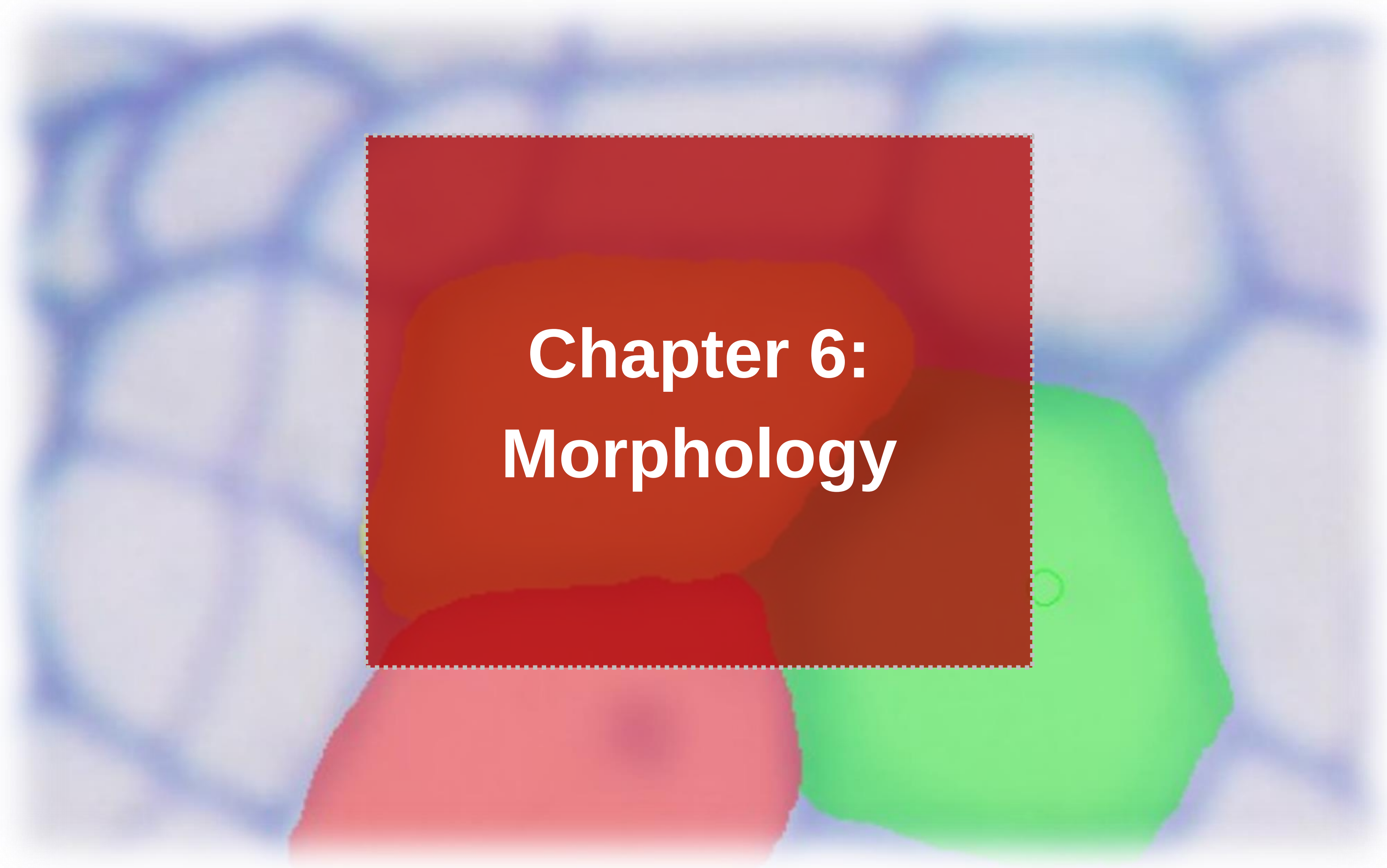
TECHNISCHE UNIVERSITÄT CHEMNITZ



# Chapter 6: Morphology

**Definition**

- Morphology is originally Greek for “concerning the shape”.
- It provides basic operations to improve images, extract features or detect shapes.

**Application**

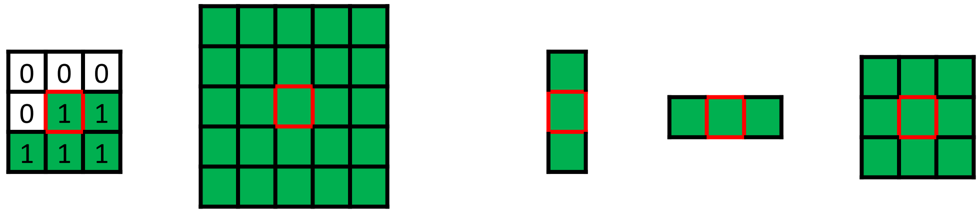
- Change shapes
- Extraction of shape features
- Edge detection
- Counting objects in an image
- Noise reduction
- Filtering

**Assumption for this lecture & exercise**

- only binary images
  (extension to greyscale images is possible)

**Masks / Structure Elements (SE)**

- Main form: rectangular mask




- A structure element (SE) is defined by its shape and size.
- The SE in morphological operations is similar to the filter kernel in the application of mathematical convolution (see chapter 4 Spatial Filtering).
- The shape is usually displayed as a binary matrix. Entries with one (green) belong to the SE, zeroes (white) do not.
- The reference point (red border) is similar to the hot spot in spatial filtering.

**Often used shapes**

- Square
- Rectangle
- Line
- Octagon
- Diamond
- Disk
- every other shape is possible

There are only two morphological base operations, dilation and erosion.
All other operations consist of a combination of those two.

### 1. Dilation

Definition:

$$F \oplus M = \{ \underline{p} : M_p \cap F \neq \emptyset \}$$

dilation operator

$F$ – set of all foreground pixels (binary image: white)

$M$ – set of all mask pixels with grey value greater than zero

$\underline{p}$ – current pixel in the image

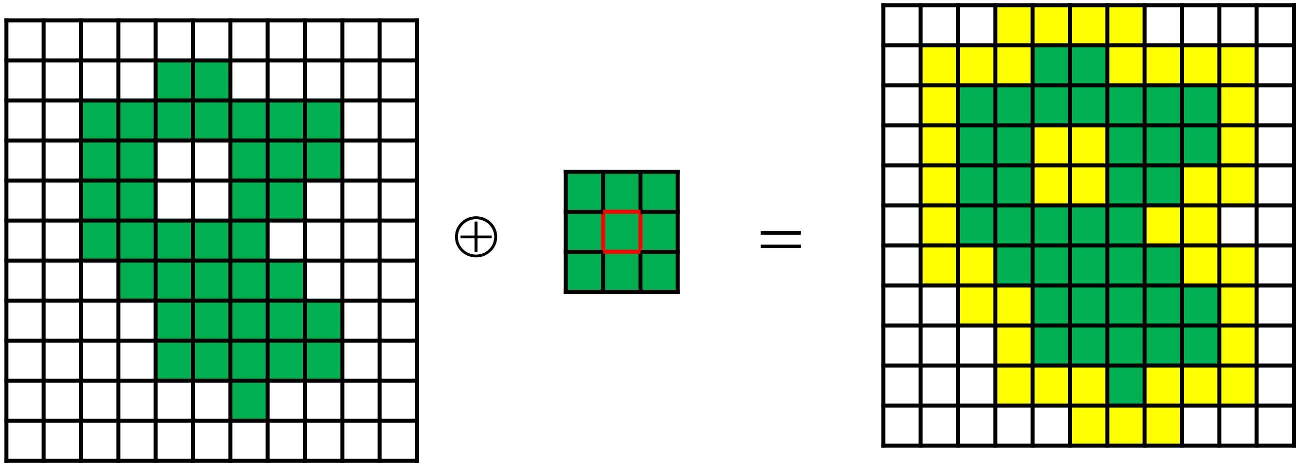
$M_p$ – shifted mask with the reference point moved to pixel $\underline{p}$

Dilation of an image $F$ with a mask $M$ is the same as the set of all pixels $\underline{p}$, where the intersection of $M_p$ and $F$ is not empty. This means, there has to be at least some overlap.

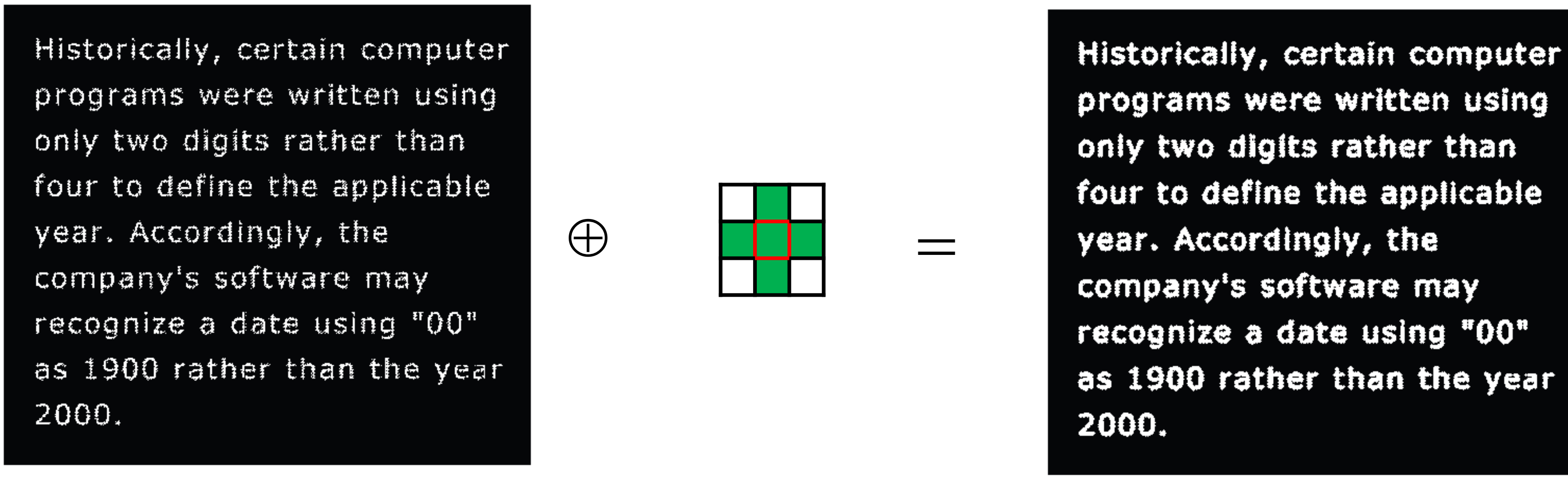
Properties:

- enlarge objects
- connect structures
- fill gaps

Dilation working scheme:

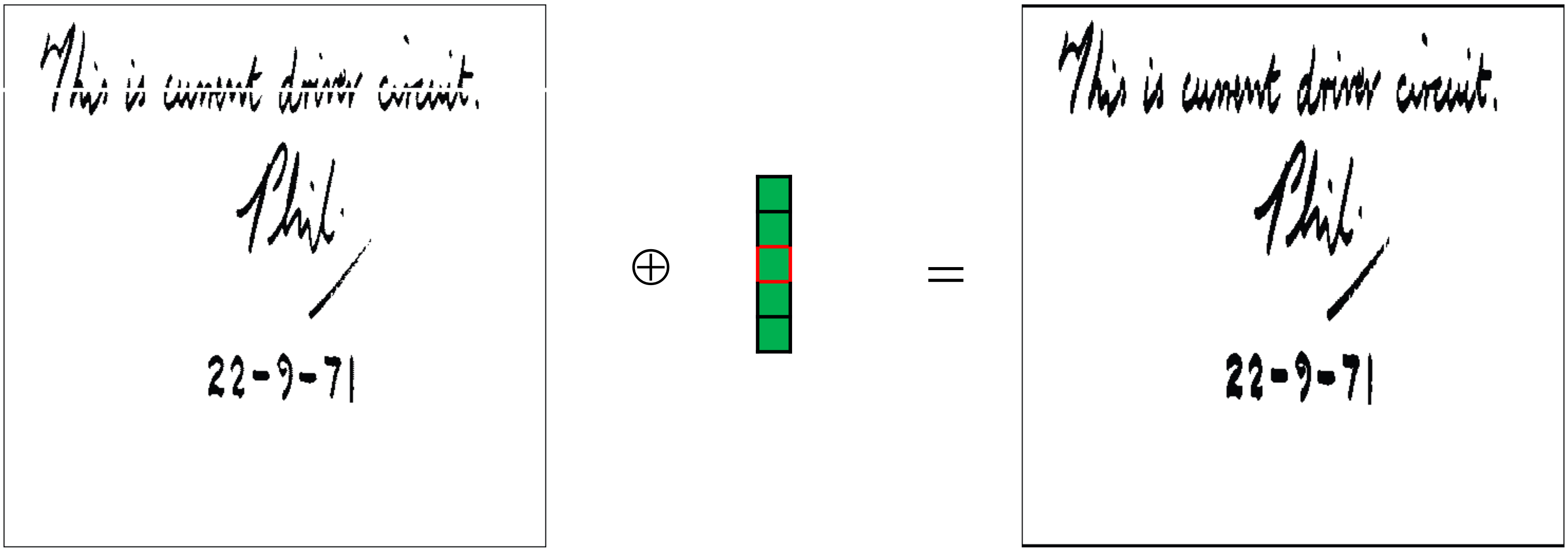


Example of dilation:




[Source: Tönnies, „*Grundlagen der Bildverarbeitung*"]

Example of dilation:




[Source: Tönnies, „*Grundlagen der Bildverarbeitung*“]

**2. Erosion**

Definition:

$$F \ominus M = \{\underline{p} : M_p \subseteq F\}$$

Erosion of an image $F$ with a mask $M$ is the same as the set of all pixels $\underline{p}$, where $M_p$ is a subset of $F$. This means, there has to be a complete overlap.

Properties:

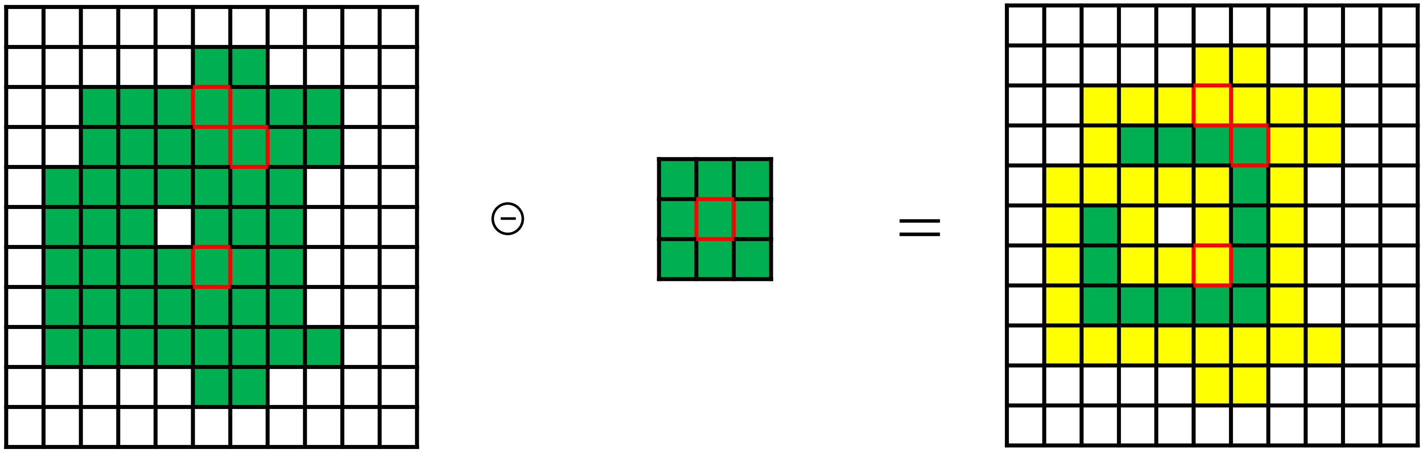
- Shrinks objects
- Removes structures, that are smaller than mask size
- Enlarges gaps/holes

Duality of erosion and dilation (valid for binary images):

$$\overline{F} \ominus M = \overline{F \oplus M}$$

$$\overline{F} \oplus M = \overline{F \ominus M}$$

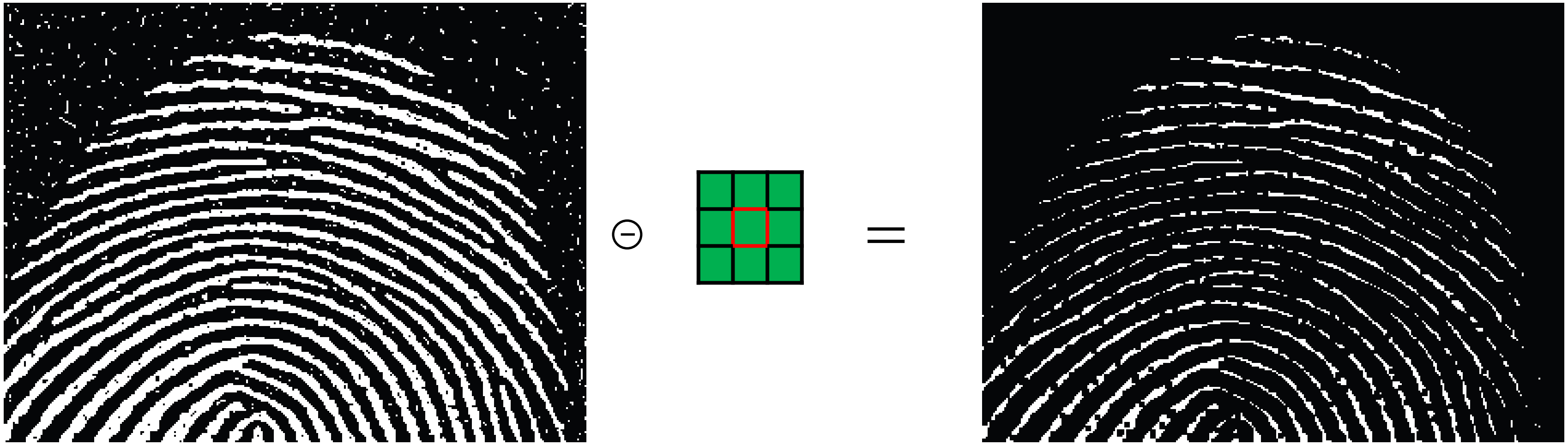
Erosion working scheme:

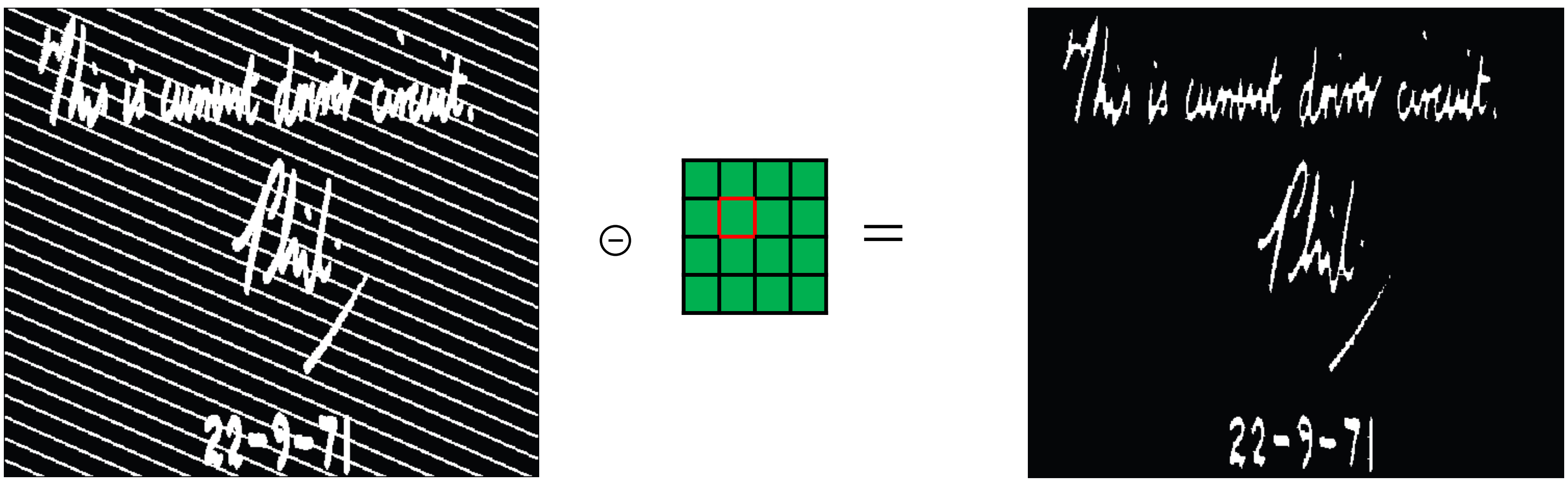


# Morphological Base Operations



Examples for erosion:




[Source: Gonzales, „*Digital Image Processing*“]

# Removing Errors in Segmentation

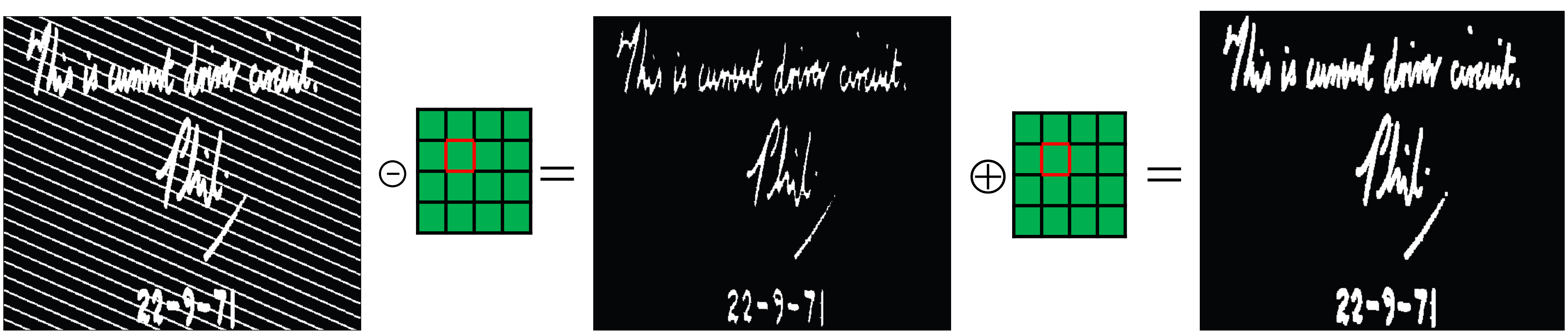


**Opening**

$$F \bigcirc M = (F \ominus M) \oplus M$$

first erosion, then dilation

- deletes small segments in image
- does not change object size



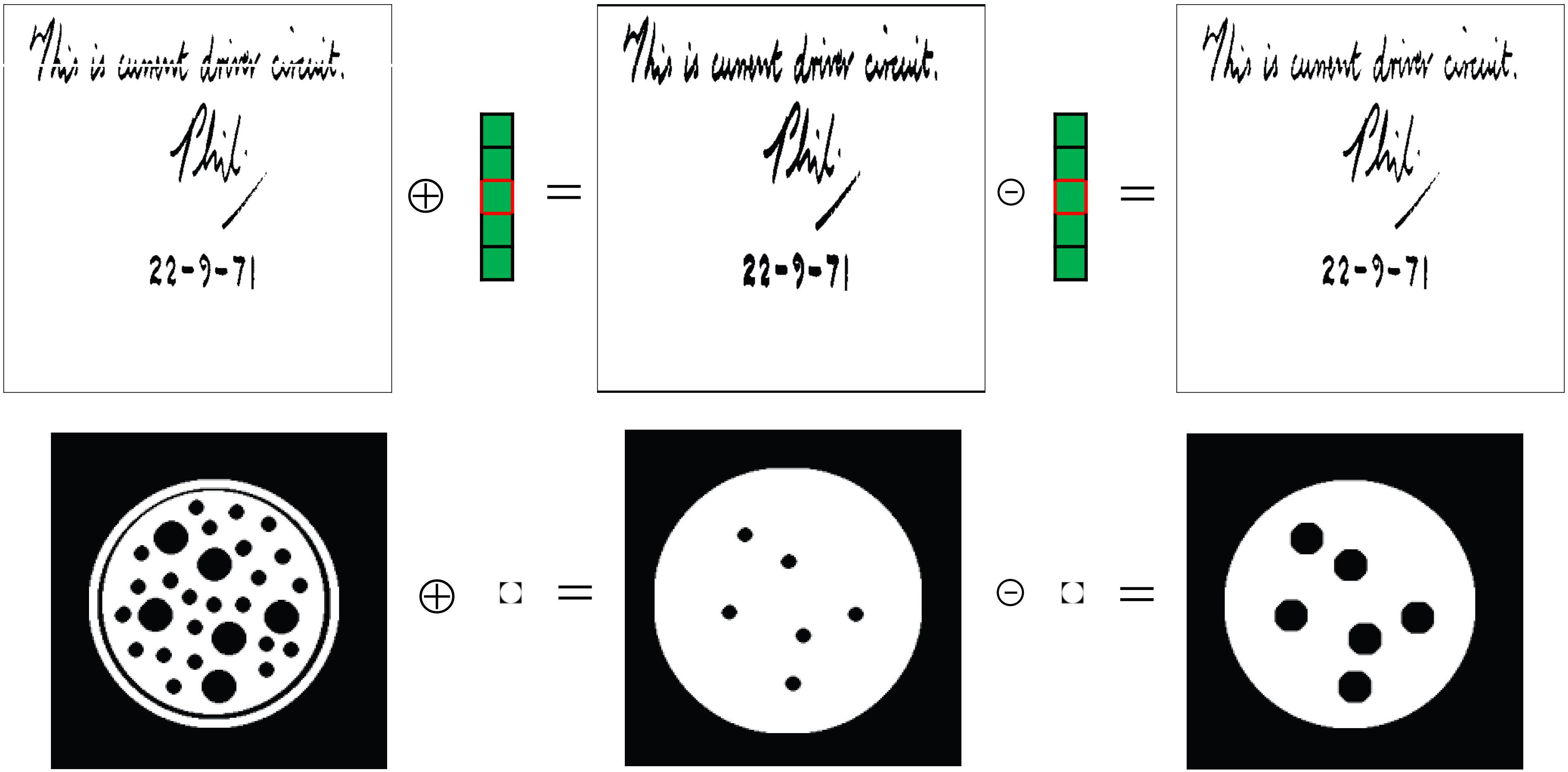

[Source: Gonzales, „*Digital Image Processing*"]

### Closing

$$F \bullet M = (F \oplus M) \ominus M$$

first dilation, then erosion

- fills small gaps in objects
- does not  change object size




[Source: Tönnies, „*Grundlagen der Bildverarbeitung*“]

**Boundary Extraction**

Algorithm:

(1) Erosion with either 3x3 mask (neighborhood of 4 or 8, see below)

➢ Removes all pixels with at least one background pixel in the neighborhood

(2) Boundary is given by the subtraction from the original image

$$B = F \setminus (F \ominus M)$$

set subtraction

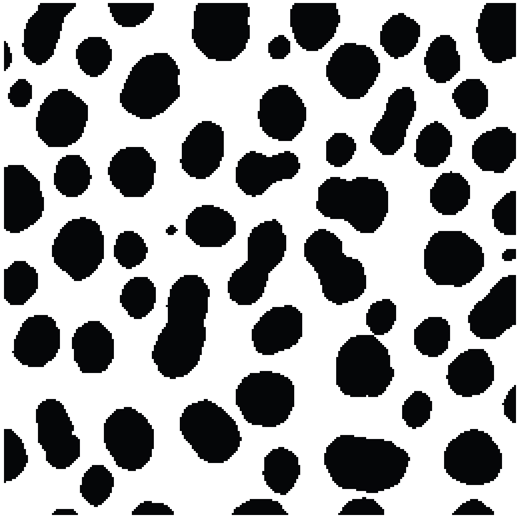
Mask:

– with two different definitions of neighborhood

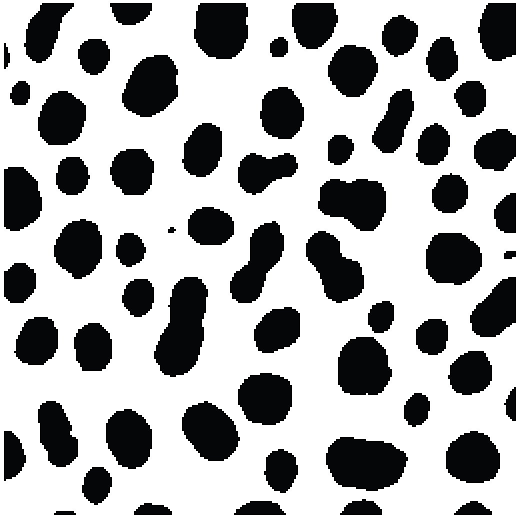
$$M_4 = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad M_8 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Example Boundary Extraction:

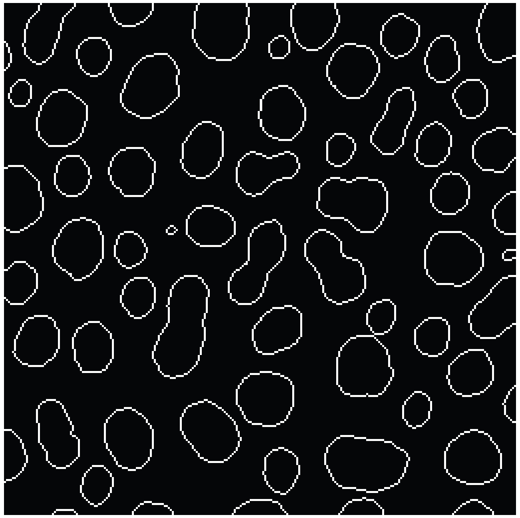
original segmentation



erosion



subtraction of the previous images

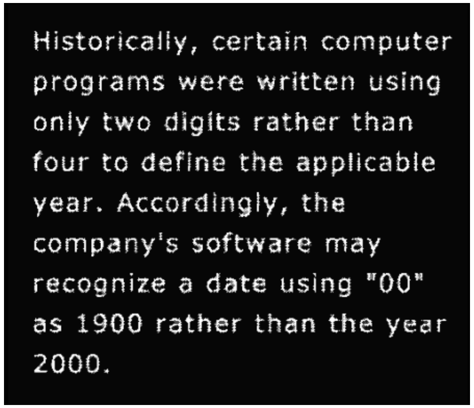


[Source:Dougherty, „*Digital Image Processing for Medical Applications*“]

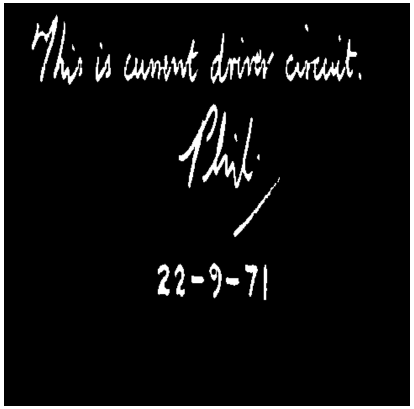
## Sixth Exercise

- Implement dilation, erosion and image subtraction.
  These are then used to perform opening, closing and boundary extraction.

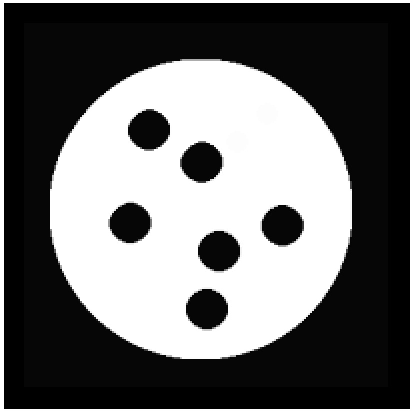
## Expected Output (1)




Closing #1



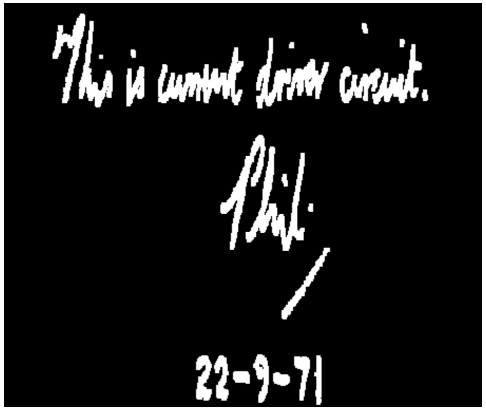

Closing #2



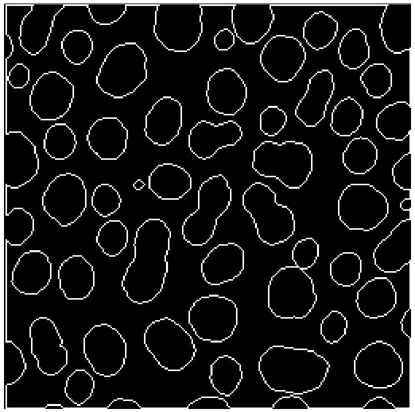
Closing #3

## Expected Output (2)

Opening #1




Opening #2



Boundary Extraction

# References


- Klaus D. Tönnies, „*Grundlagen der Bildverarbeitung“, Pearson Studium, 1. Auflage, 2005*
- Bernd Jähne, „*Digitale Bildverarbeitung“, Springer, 6. Auflage, 2005*
- Rafael C. Gonzales and Richard E. Woods, „*Digital Image Processing“, Pearson International, 3. Edition, 2008*
- Geoff Dougherty, „*Digital Image Processing for Medical Applications“, Cambridge University Press, 1. Edition, 2009*