

VC 17/18 – TP9

Region-Based Segmentation

Mestrado em Ciência de Computadores
Mestrado Integrado em Engenharia de Redes e
Sistemas Informáticos

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Outline

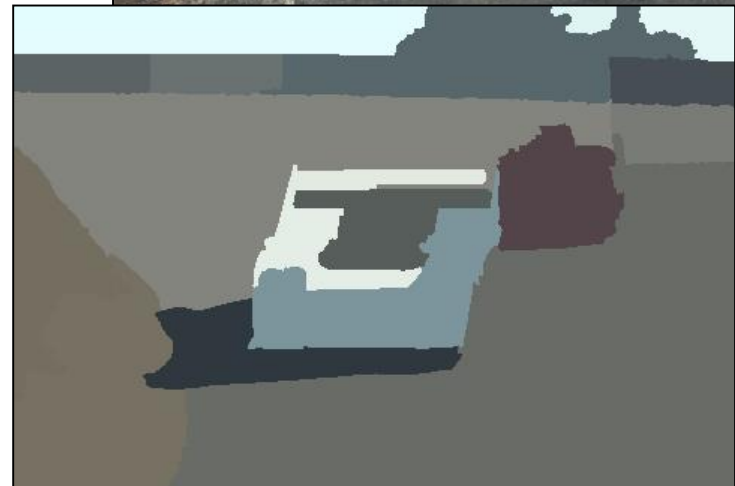
- Region-based Segmentation
- Morphological Filters

Topic: Region-based Segmentation

- Region-based Segmentation
- Morphological Filters

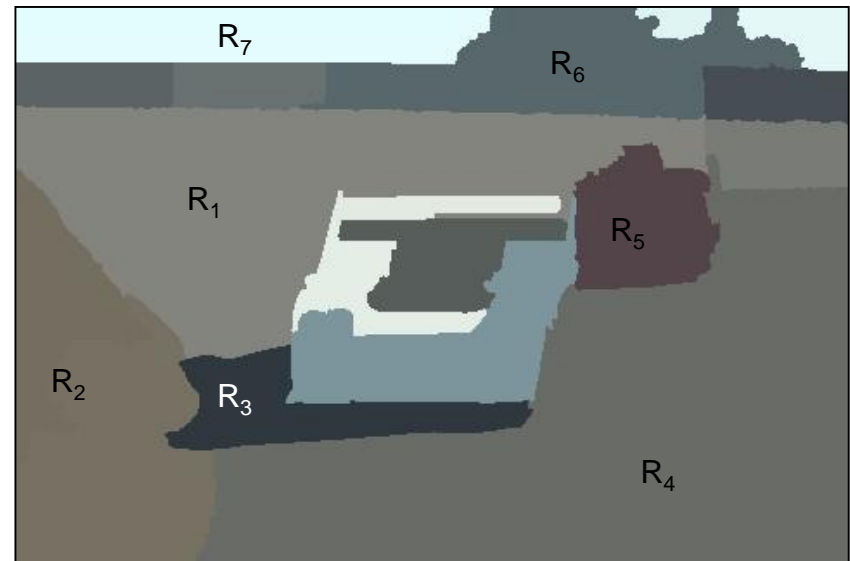
Why Region-Based Segmentation?

- **Segmentation**
 - Edge detection and Thresholding not always effective.
- **Homogenous regions**
 - *Region-based segmentation.*
 - Effective in noisy images.

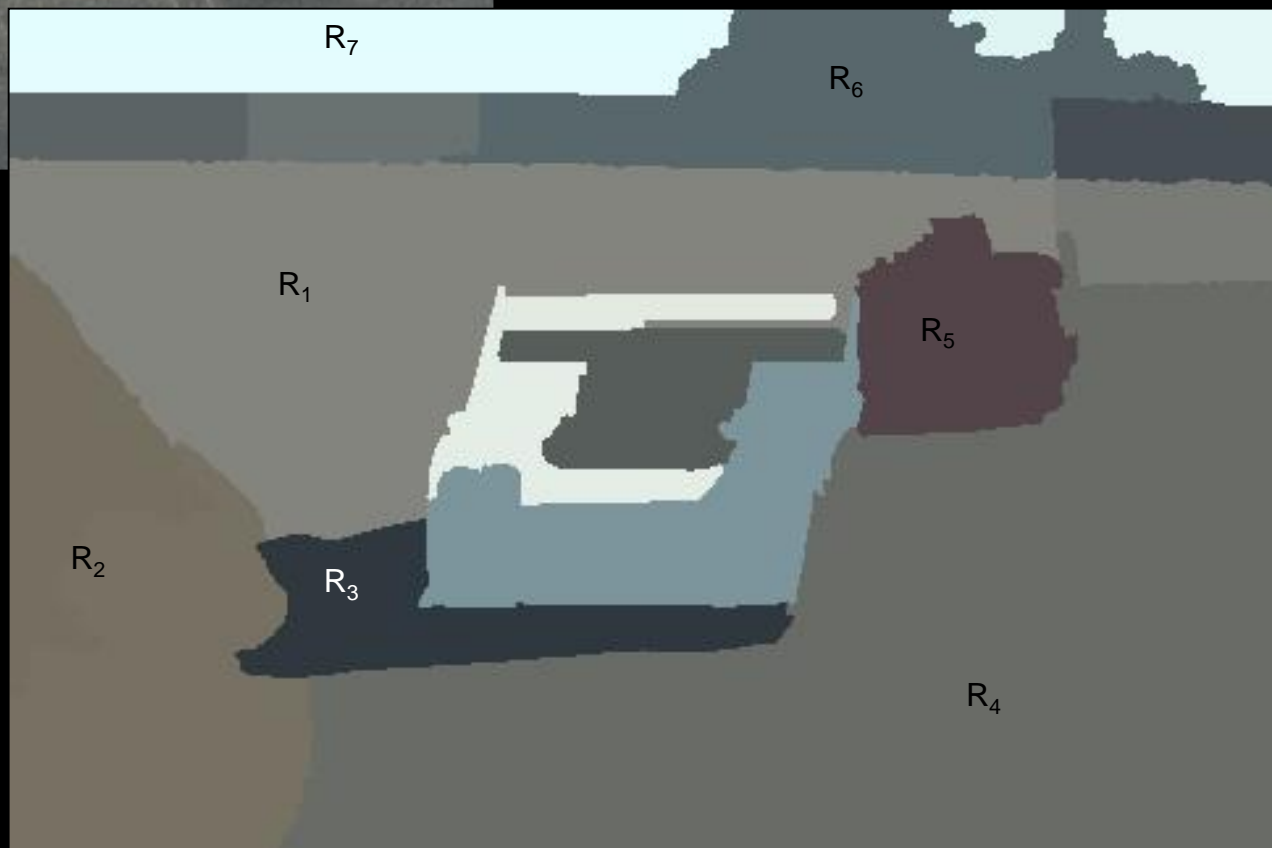


Definitions

- Based on *sets*.
- Each image R is a set of regions R_i .
 - Every pixel belongs to one region.
 - One pixel can only belong to a single region.



$$R = \bigcup_{i=1}^S R_i \quad R_i \cap R_j = \emptyset$$



Basic Formulation

Let R represent the entire image region. Segmentation partitions R into n subregions, R_1, R_2, \dots, R_n , such that:

a) $\bigcup_{i=1}^n R_i = R$

b) R_i is a connected region, $i = 1, 2, \dots, n$.

c) $R_i \cap R_j = \emptyset$ for all i and $j, i \neq j$

d) $P(R_i) = \text{TRUE}$ for $i = 1, 2, \dots, n$.

e) $P(R_i \cup R_j) = \text{FALSE}$ for $i \neq j$.

a) Every pixel must be in a region

b) Points in a region must be connected.

c) Regions must be disjoint.

d) All pixels in a region satisfy specific properties.

e) Different regions have different properties.

How do we form regions?

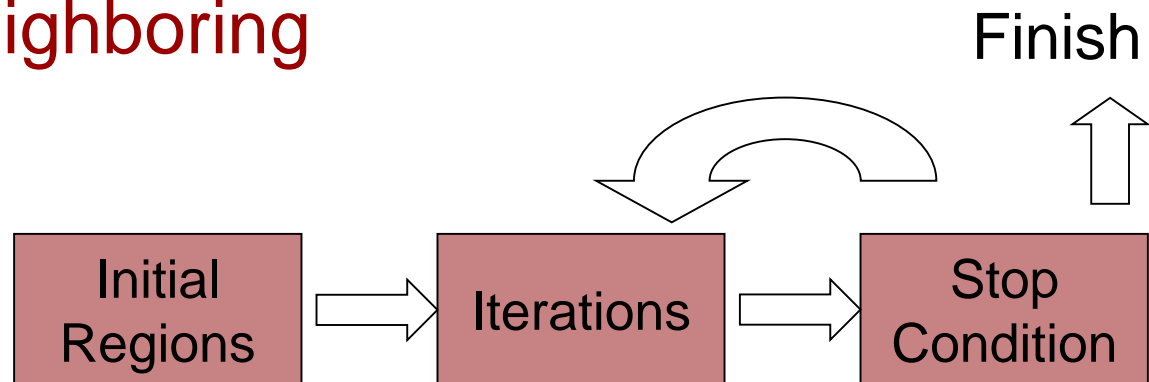
- Region Growing
- Region Merging
- Region Splitting
- Split and Merge
- Watershed
- ...

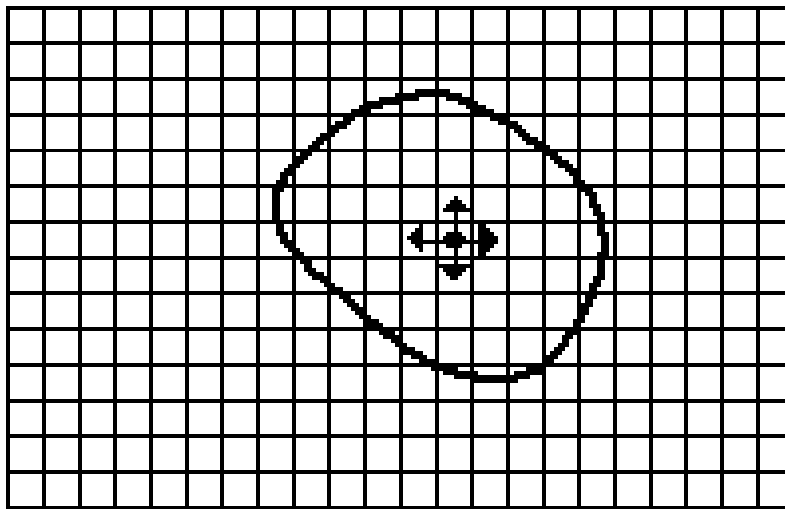
0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

Region growing

- Groups pixels into larger regions.
- Starts with a **seed** region.
- **Grows** region by **merging** neighboring pixels.
- **Iterative process**
 - How to start?
 - How to iterate?
 - When to stop?

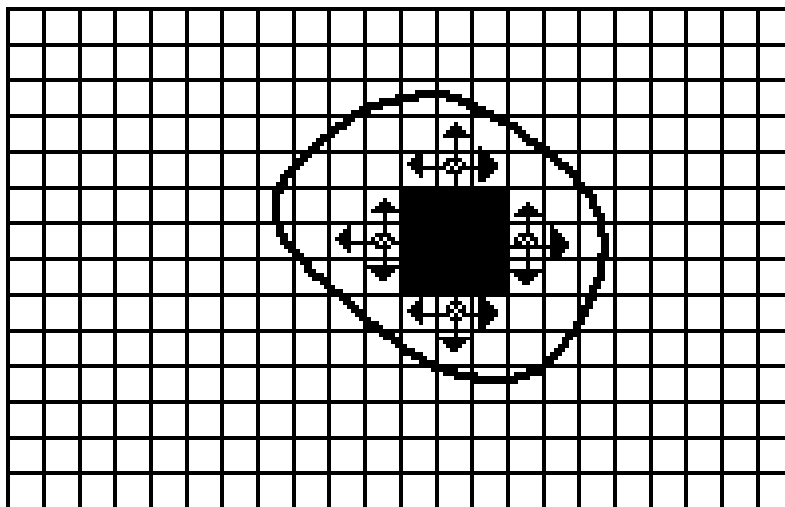




• Seed Pixel

↑ Direction of Growth

(a) Start of Growing a Region



■ Grown Pixels

⊙ Pixels Being Considered

(b) Growing Process After a Few Iterations

Region merging

- **Algorithm**
 - Divide image into an initial set of regions.
 - One region per pixel.
 - Define a **similarity criteria** for merging regions.
 - **Merge** similar regions.
 - Repeat previous step until no more merge operations are possible.

Similarity Criteria

- Homogeneity of regions is used as the main segmentation criterion in region growing.
 - gray level
 - color, texture
 - shape
 - model
 - etc.

Choice of criteria affects segmentation results dramatically!

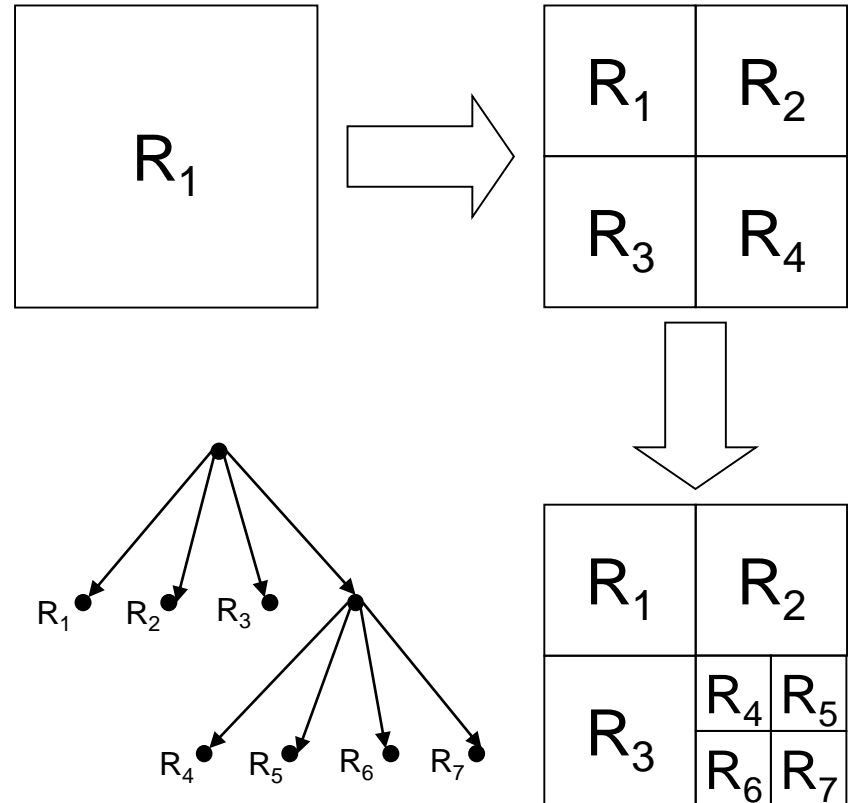
Gray-Level Criteria

- **Comparing to Original Seed Pixel**
 - Very sensitive to choice of **seed point**.
- **Comparing to Neighbor in Region**
 - Allows gradual changes in the region.
 - Can cause significant drift.
- **Comparing to Region Statistics**
 - Acts as a **drift dampener**.
- **Other possibilities!**

Region splitting

- **Algorithm**

- One initial set that includes the **whole image**.
- **Similarity criteria.**
- Iteratively **split** regions into sub-regions.
- Stop when no more splittings are possible.



The segmentation problem

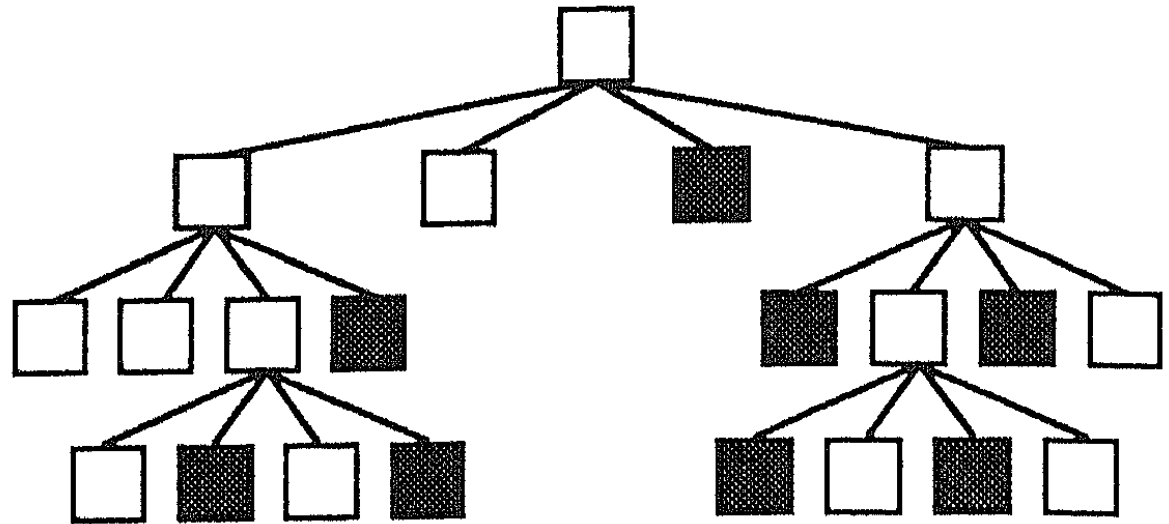
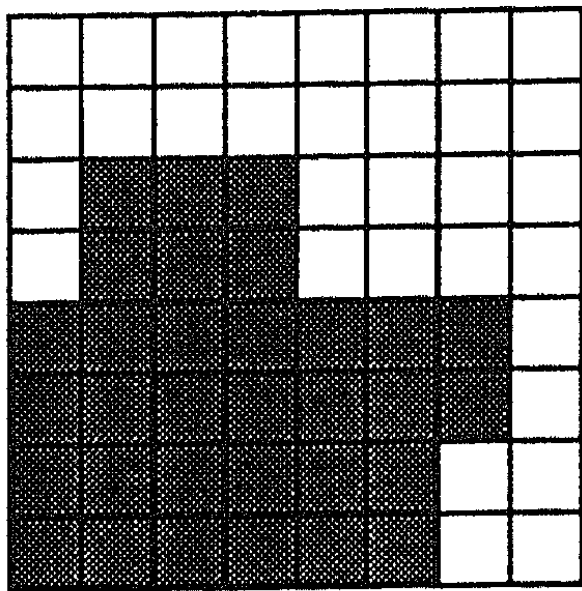
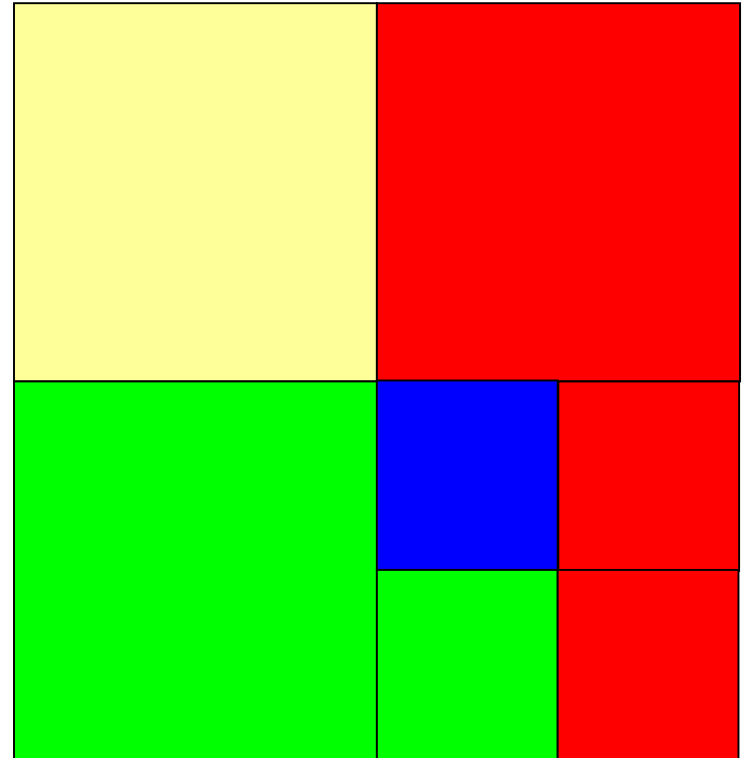


Figure 5.23 A quad-tree representation of an 8×8 binary image.

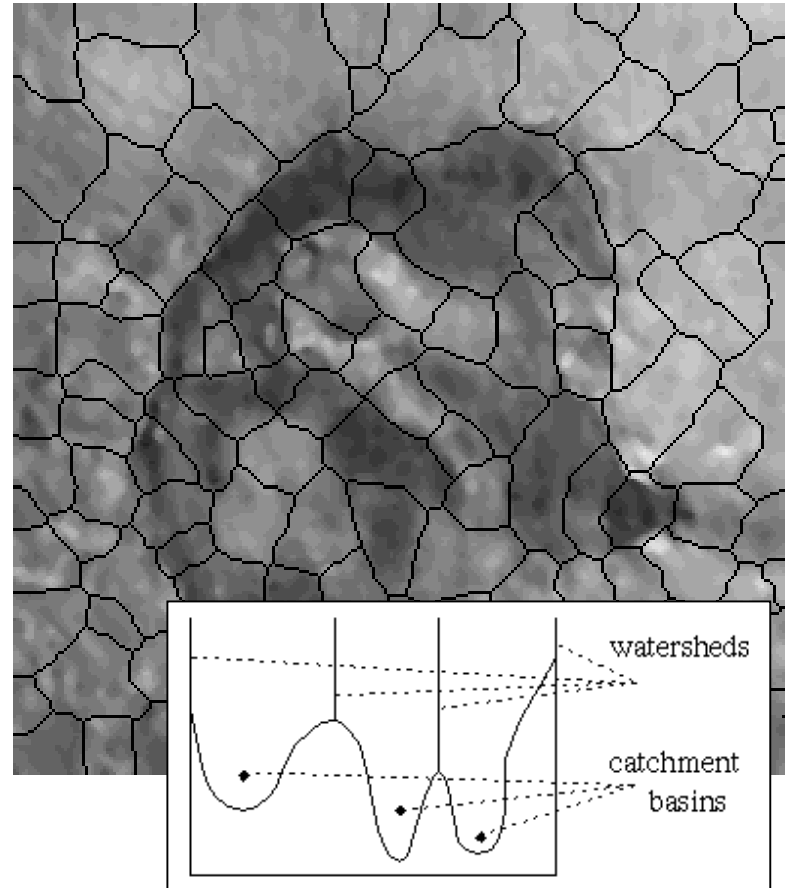
Split and Merge

- Combination of both algorithms.
- Can handle a larger variety of shapes.
 - Simply apply previous algorithms consecutively.



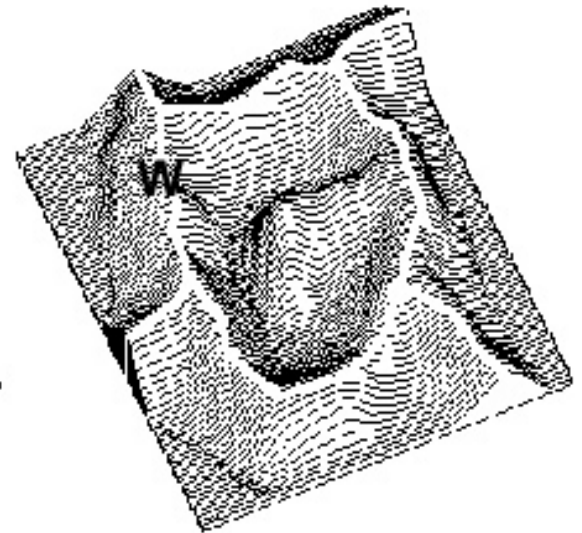
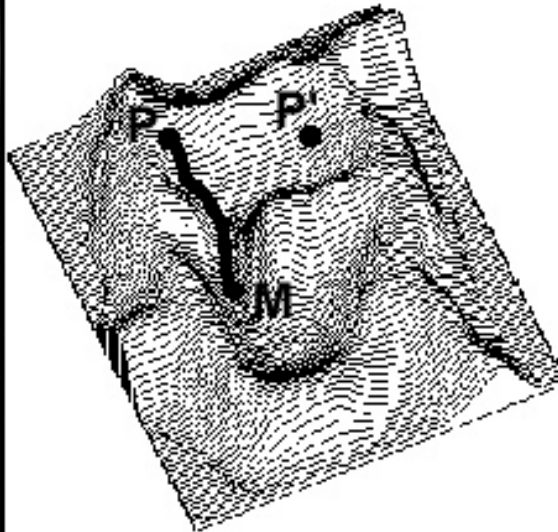
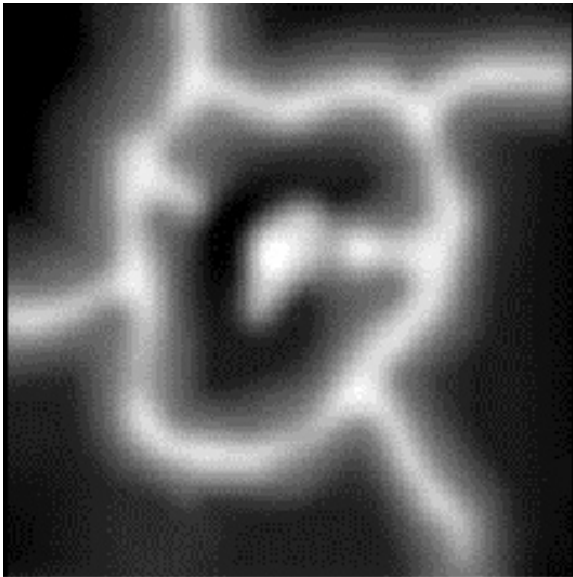
The *Watershed* Transform

- **Geographical inspiration.**
 - Shed water over rugged terrain.
 - Each lake corresponds to a region.
- **Characteristics**
 - Computationally complex.
 - Great flexibility in segmentation.
 - Risk of over-segmentation.



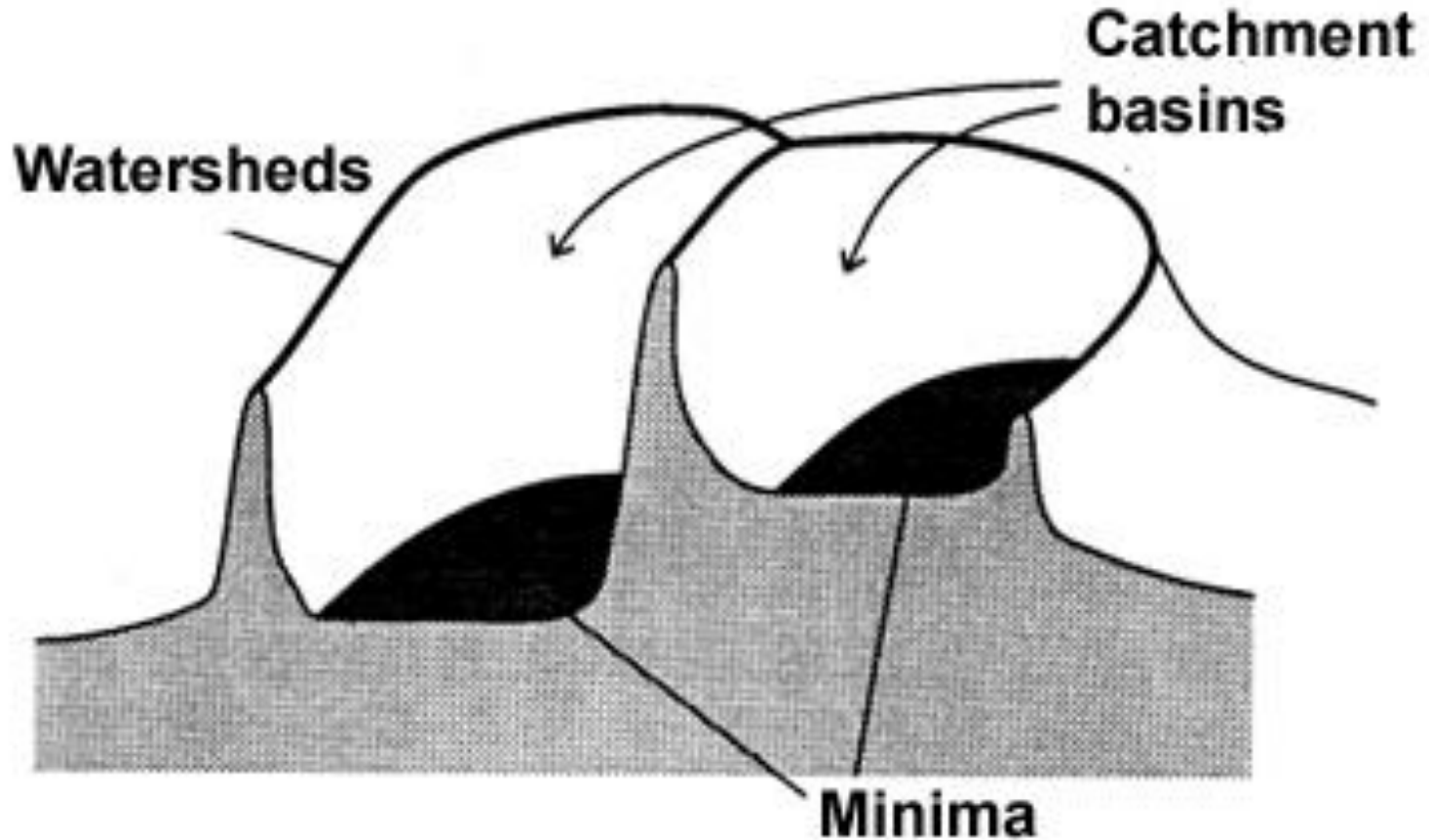
The Drainage Analogy

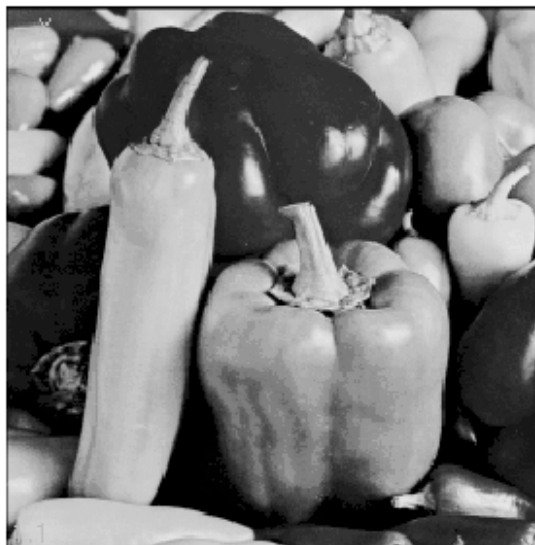
- Two points are in the same region if they drain to the same point.



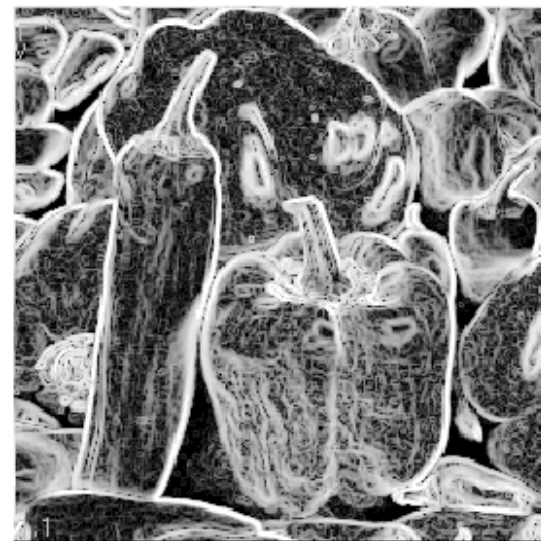
Courtesy of Dr. Peter Yim at National Institutes of Health, Bethesda, MD

The Immersion Analogy





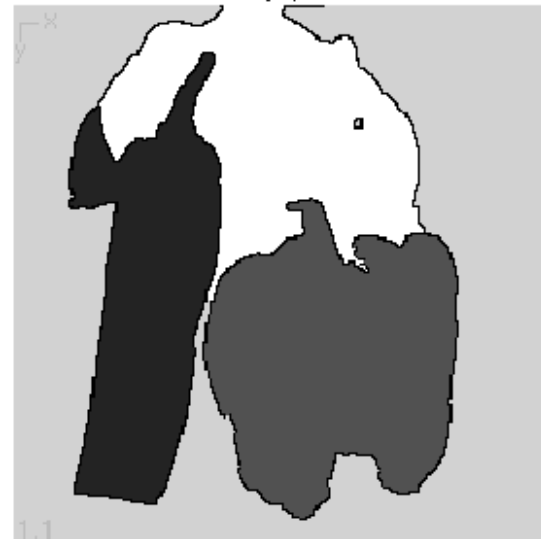
(a)



(b)



(c)



(d)

[Milan Sonka,
Vaclav Hlavac,
and Roger Boyle]

Figure 5.51: *Watershed segmentation: (a) original; (b) gradient image, 3×3 Sobel edge detection, histogram equalized; (c) raw watershed segmentation; (d) watershed segmentation using region markers to control oversegmentation. Courtesy W. Higgins, Penn State University.*

Over-Segmentation

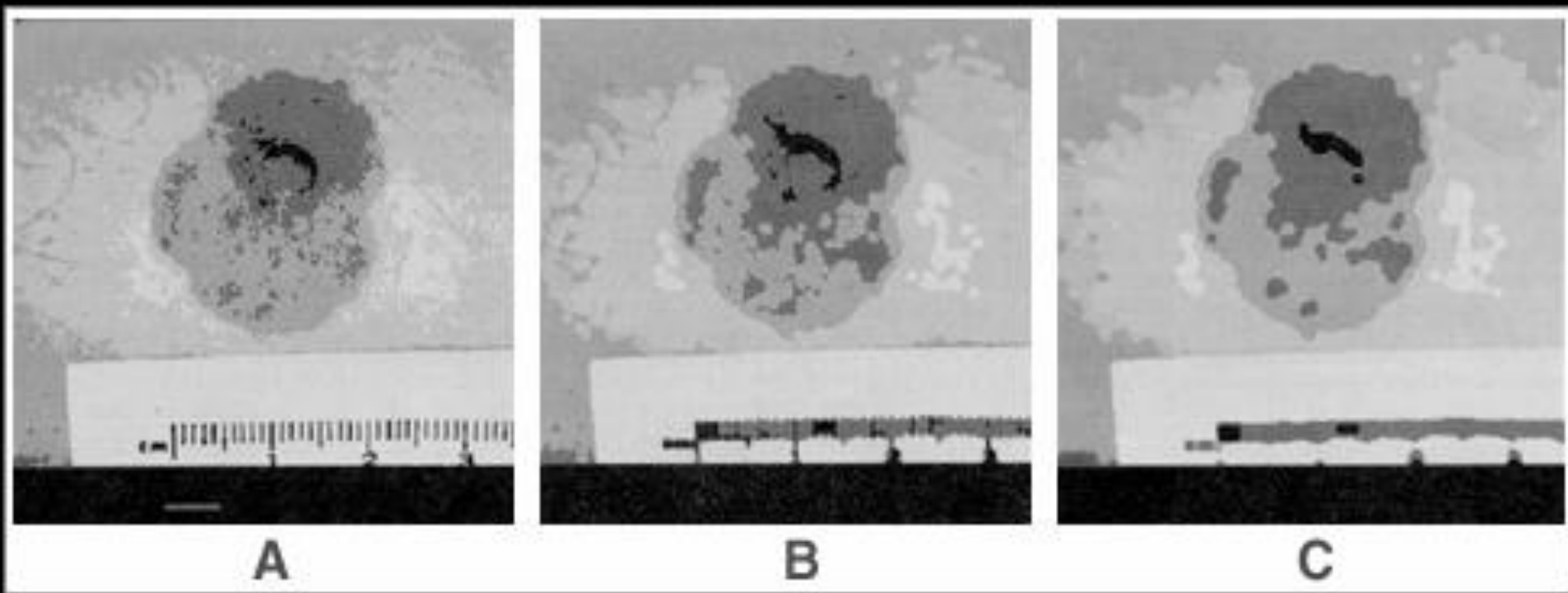
- **Over-segmentation.**
 - Raw watershed segmentation produces a severely oversegmented image with hundreds or thousands of catchment basins.
- **Post-Processing.**
 - Region merging.
 - Edge information.
 - Etc.

Topic: Morphological Filters

- Region-based Segmentation
- **Morphological Filters**

Mathematical Morphology

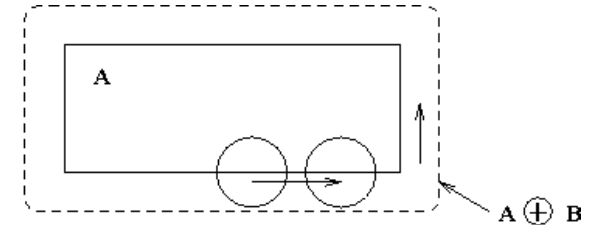
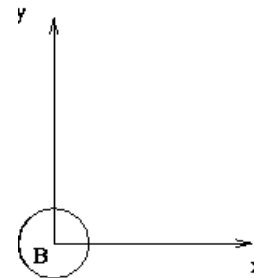
- Provides a mathematical description of geometric structures.
- Based on *sets*.
 - Groups of pixels which define an image region.
- What is this used for?
 - Binary images.
 - Can be used for **post-processing** segmentation results!
- Core techniques
 - Erosion, Dilation.
 - Open, Close.



Tumor Segmentation using Morphologic Filtering

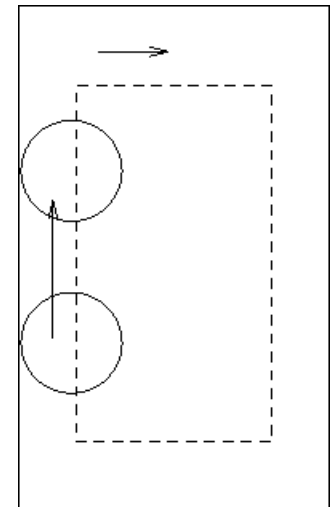
Dilation, Erosion

- **Two sets:**
 - Image
 - Morphological *kernel*.
- **Dilation (D)**
 - Union of the **kernel** with the **image** set.
 - Increases resulting area.
- **Erosion (E)**
 - Intersection.
 - Decreases resulting area.



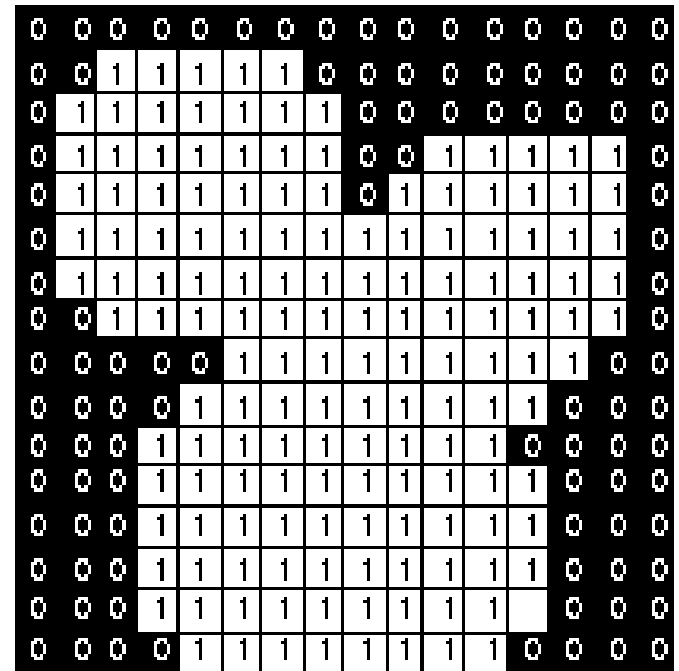
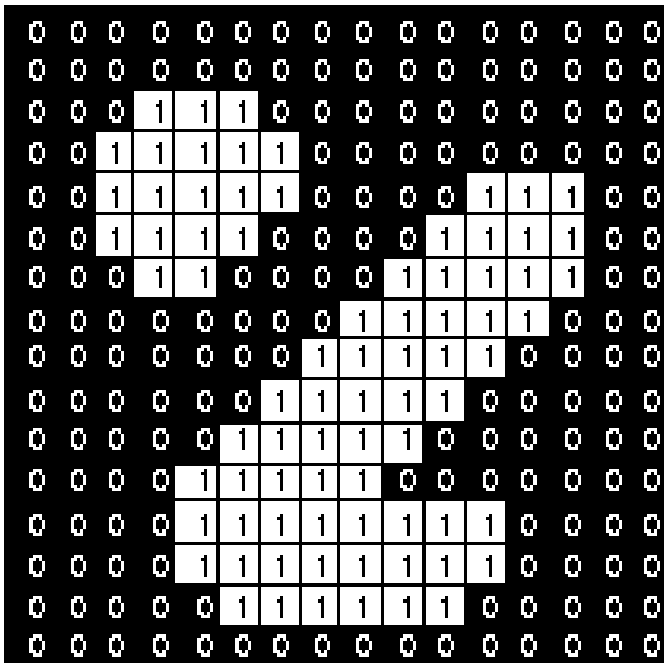
$$D(A, B) = A \oplus B = \bigcup_{\beta \in B} (A + \beta)$$

$$E(A, B) = A \ominus B = \bigcap_{\beta \in B} (A - \beta)$$



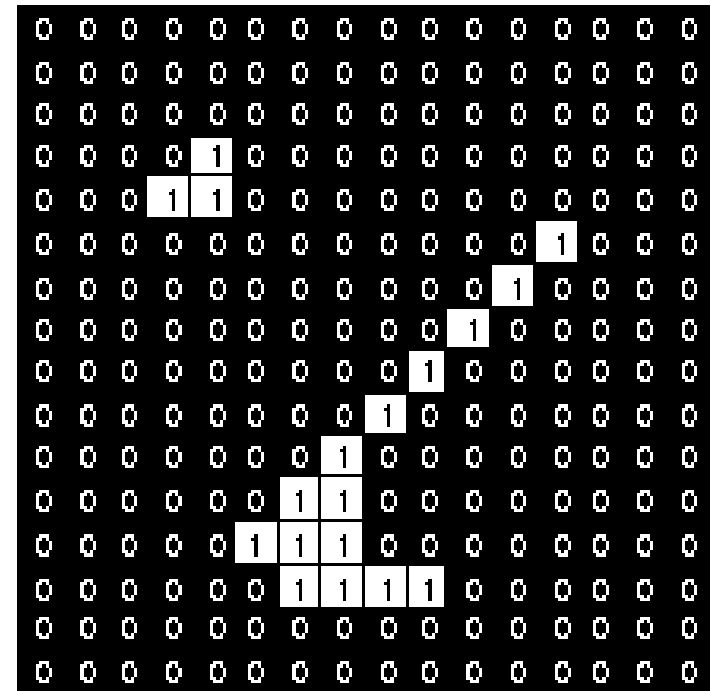
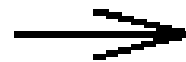
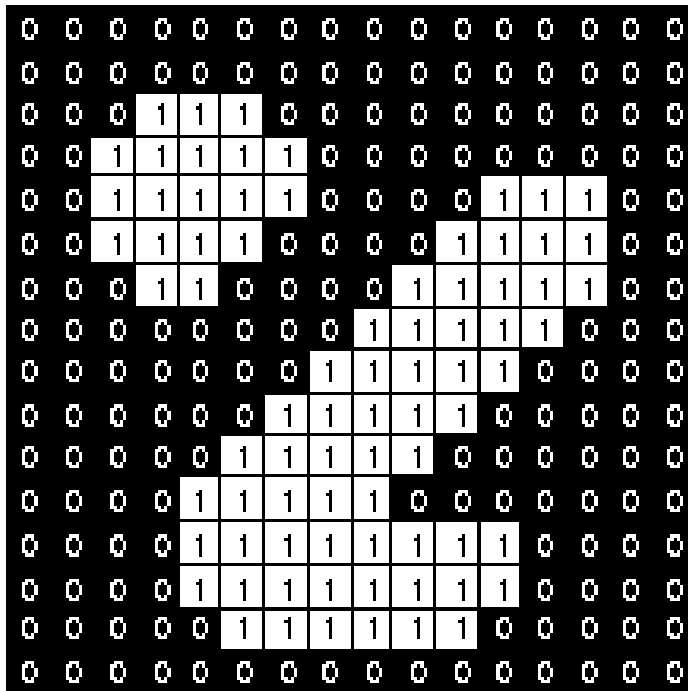
Dilation

- Example using a 3x3 morphological kernel



Erosion

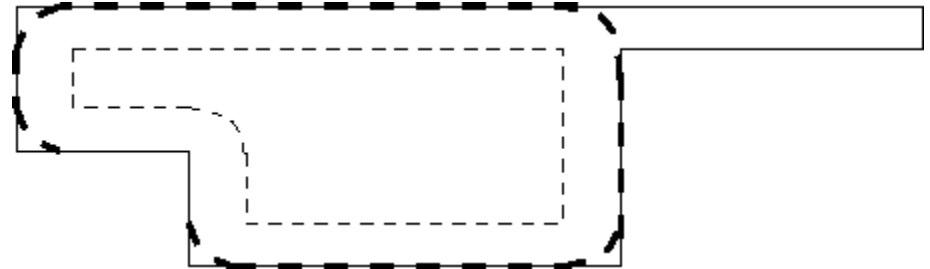
- Example using a 3x3 morphological kernel



Opening, Closing

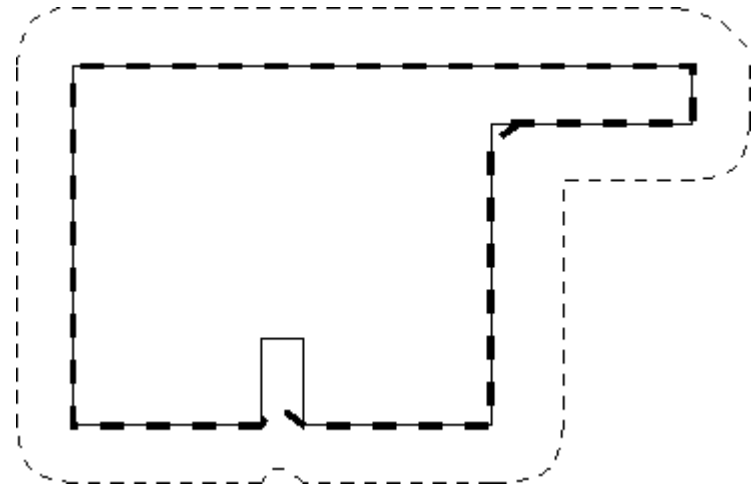
- **Opening**

- **Erosion**, followed by **dilation**.
- Less destructive than an erosion.
- **Adapts** image shape to kernel shape.



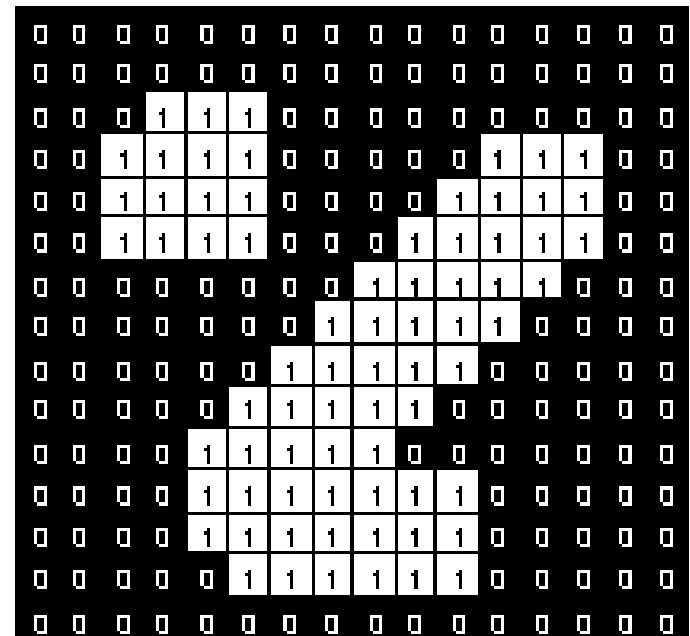
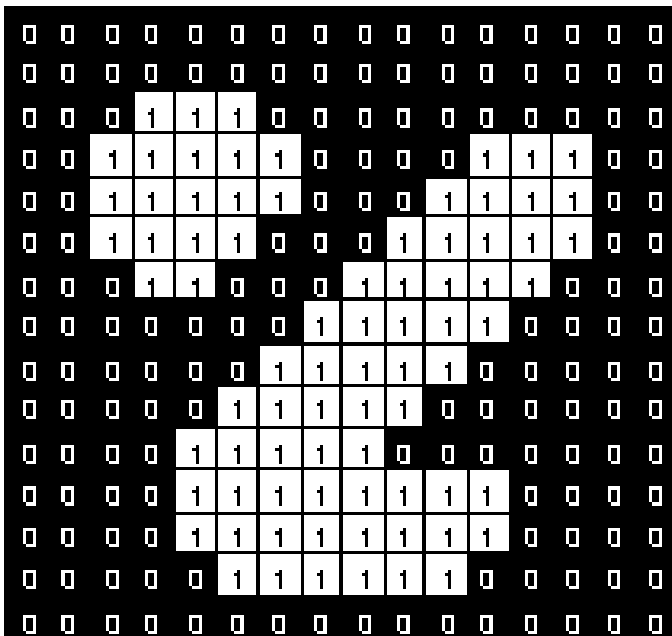
- **Closing**

- **Dilation**, followed by **erosion**.
- Less destructive than a dilation.
- Tends to **close** shape irregularities.



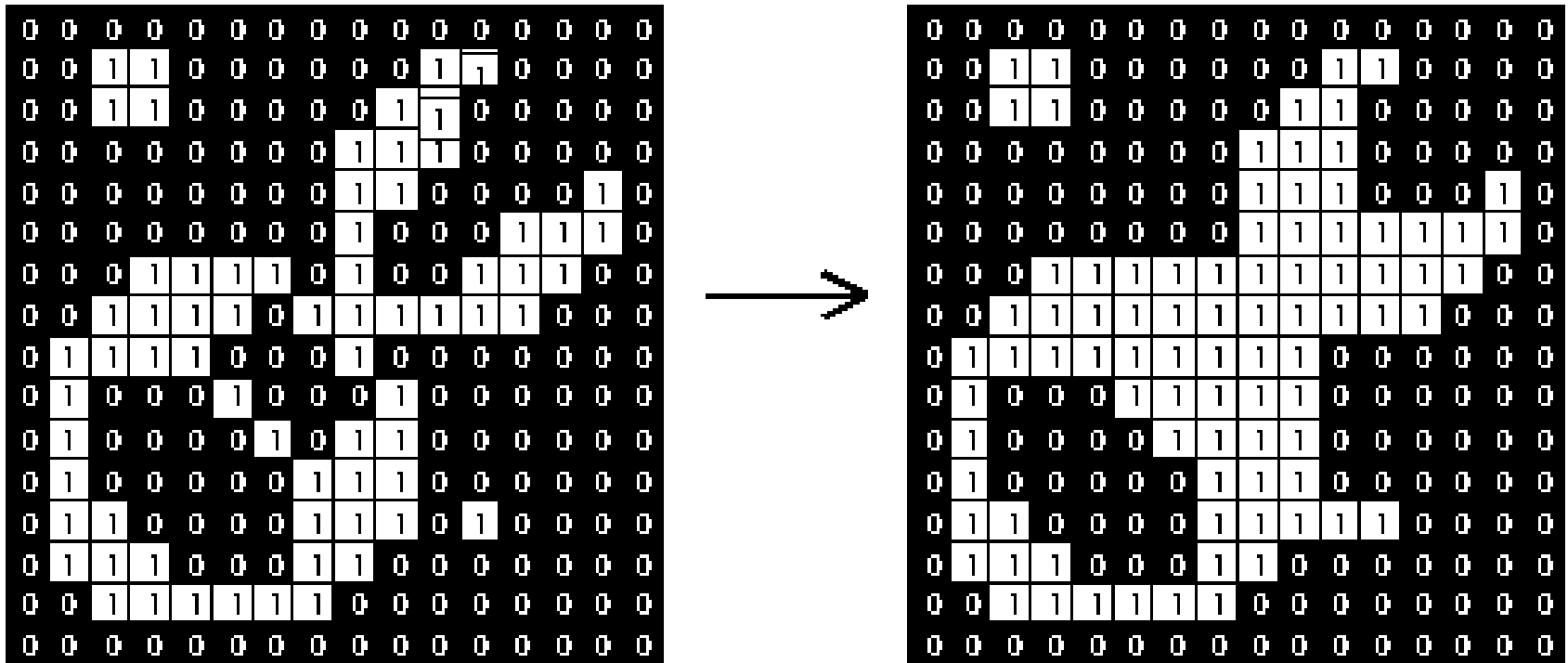
Opening

- Example using a 3x3 morphological kernel



Closing

- Example using a 3x3 morphological kernel



Core morphological operators



Dilation



Erosion

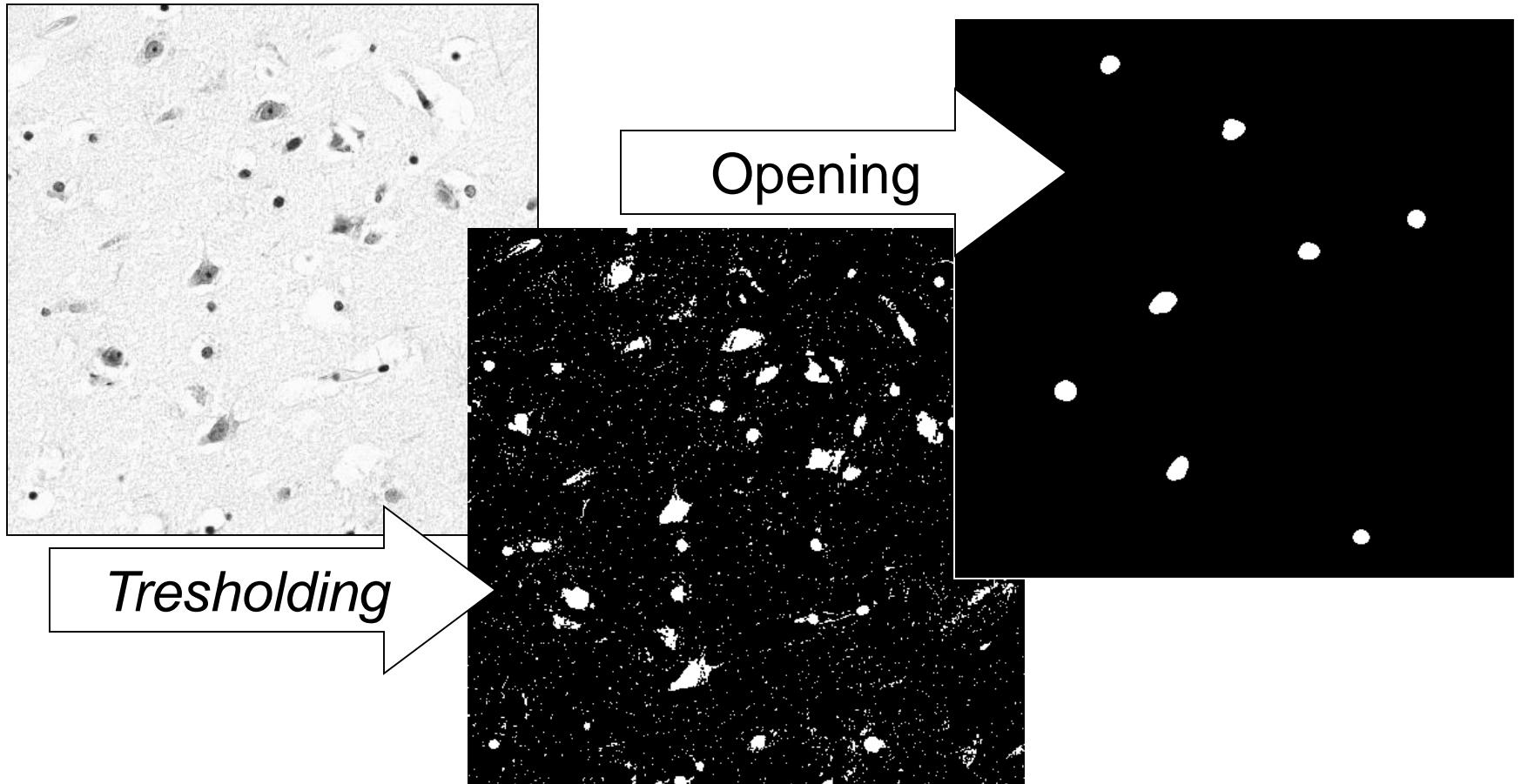


Closing

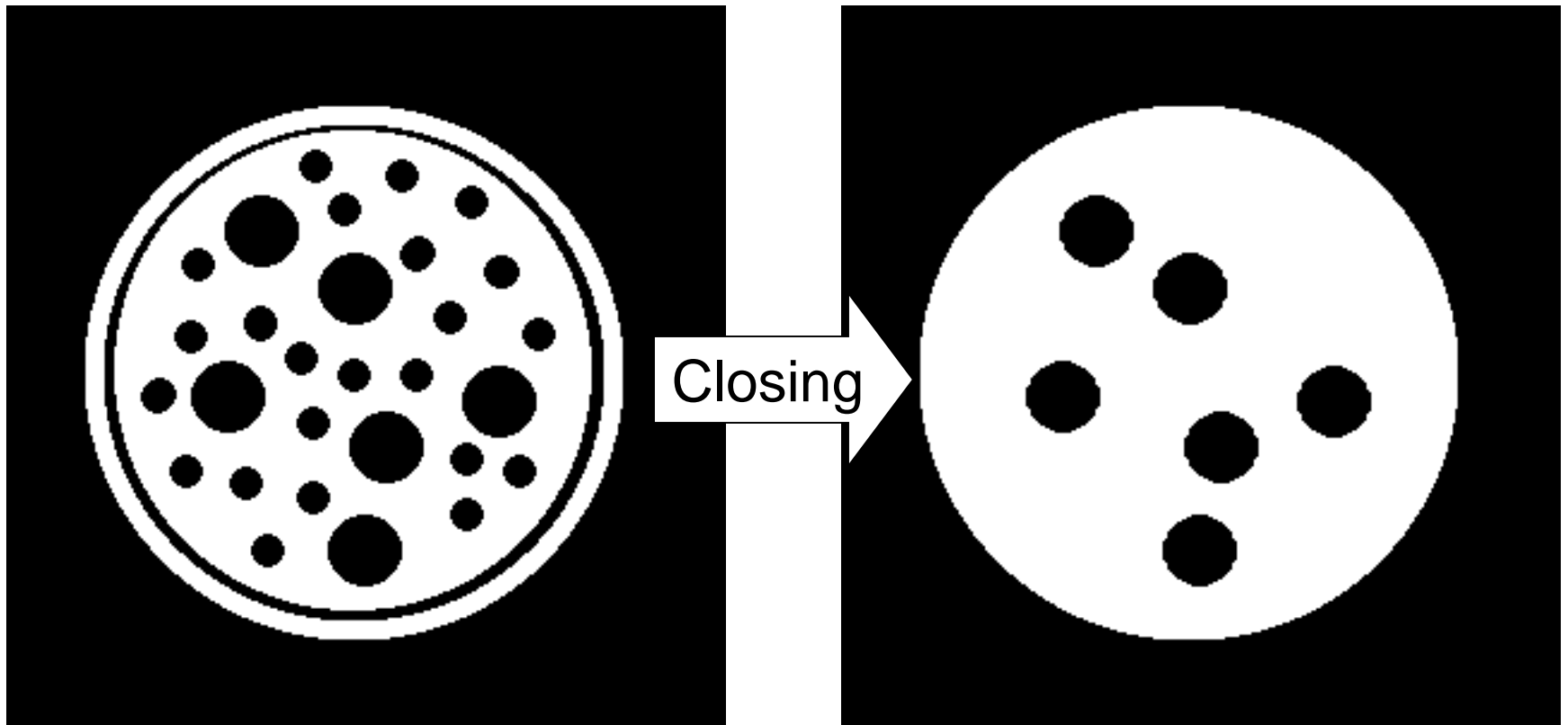


Opening

Example: Opening

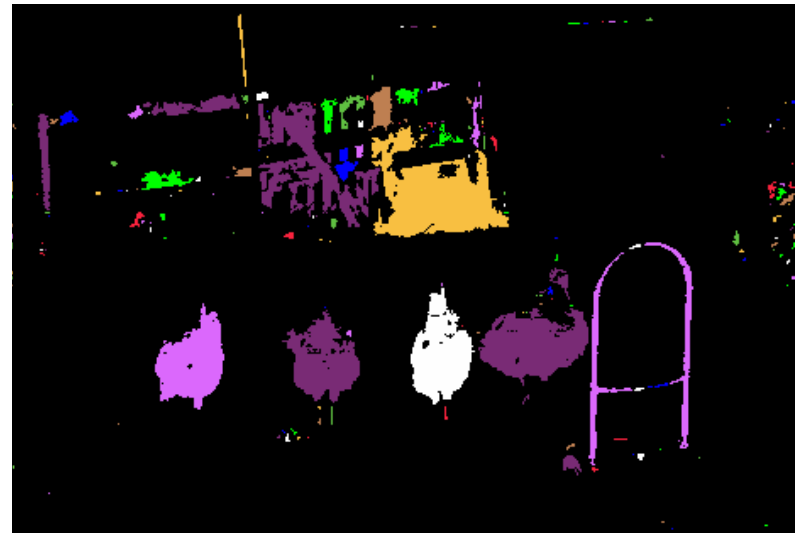
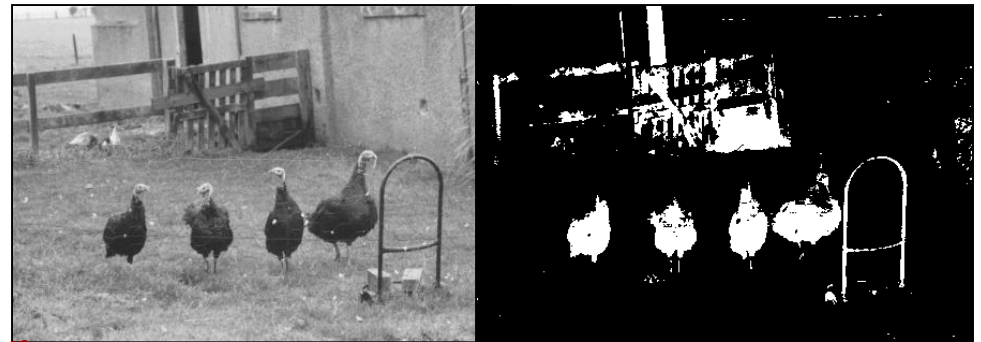


Example: Closing



Connected Component Analysis

- Define '**connected**'.
 - 4 neighbors.
 - 8 neighbors.
- Search the image for **seed points**.
- Recursively obtain all **connected points** of the seeded region.



Resources

- Gonzalez & Woods - Chapter 7 and 8