Digital Image Processing (DIP)

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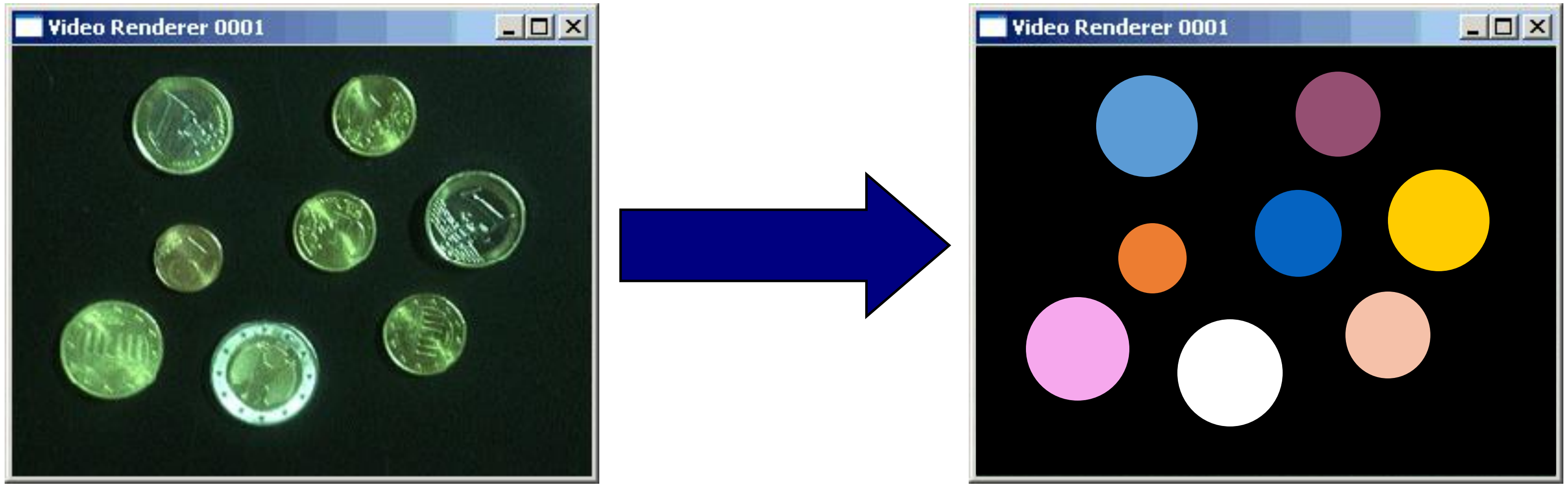
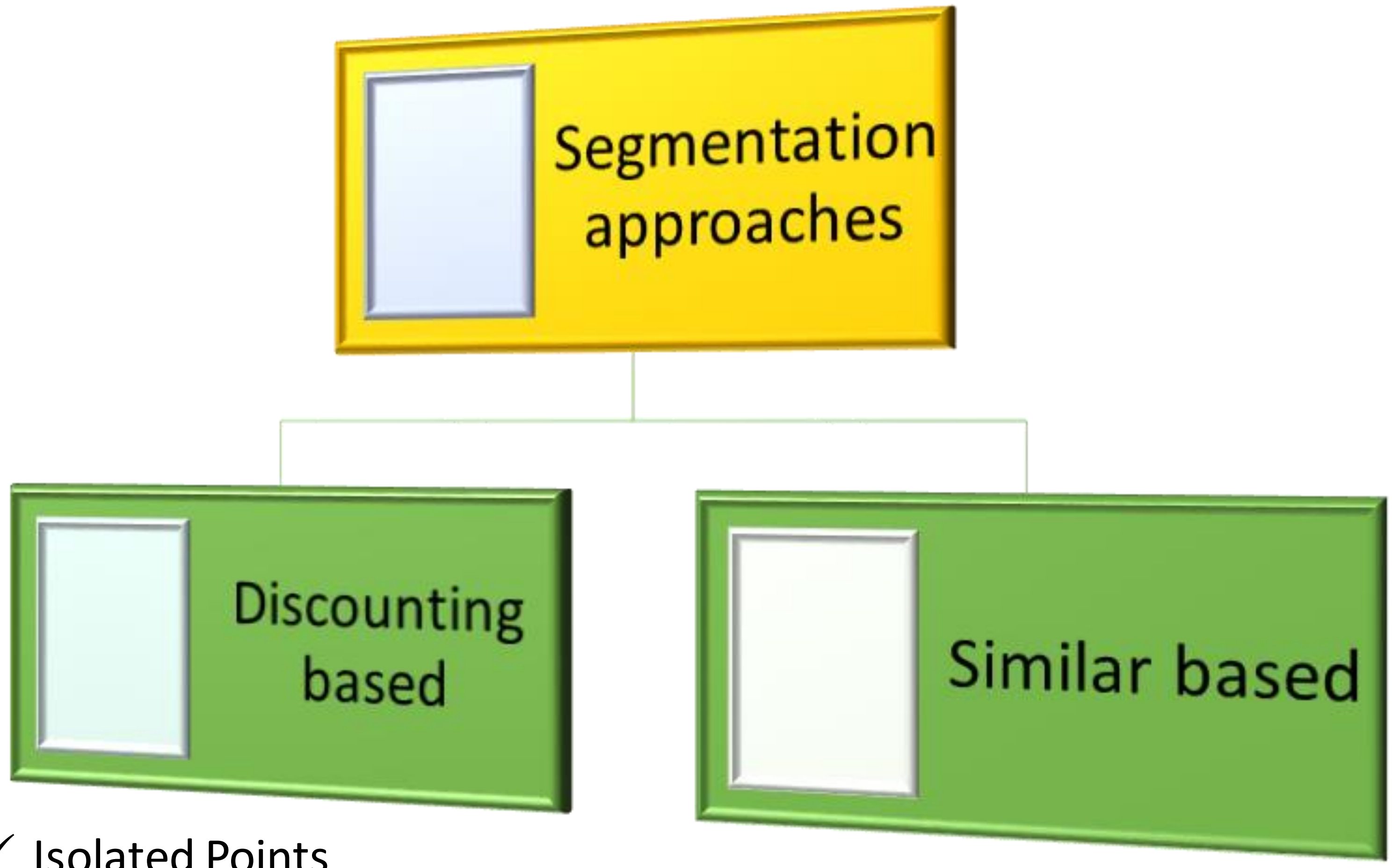
Computer Vision

The Segmentation Problem

- Segmentation attempts to partition the pixels of an image into groups that strongly correlate with the objects in an image
- Typically the first step in any automated computer vision application





- ✓ Isolated Points
- ✓ Line
- ✓ Edge
- ✓ ....

- ✓ Thresholding
- ✓ Region growing
- ✓ ...

Detection Of Discontinuities

- There are three basic types of grey level discontinuities that we tend to look for in digital images:
  - Points
  - Lines
  - Edges
- We typically find discontinuities using masks and correlation

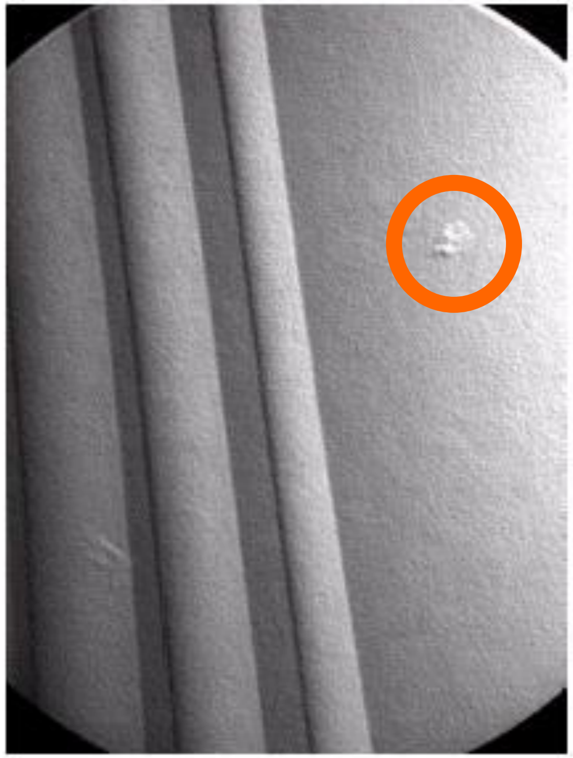
Point Detection

Point detection can be achieved simply using the mask below:

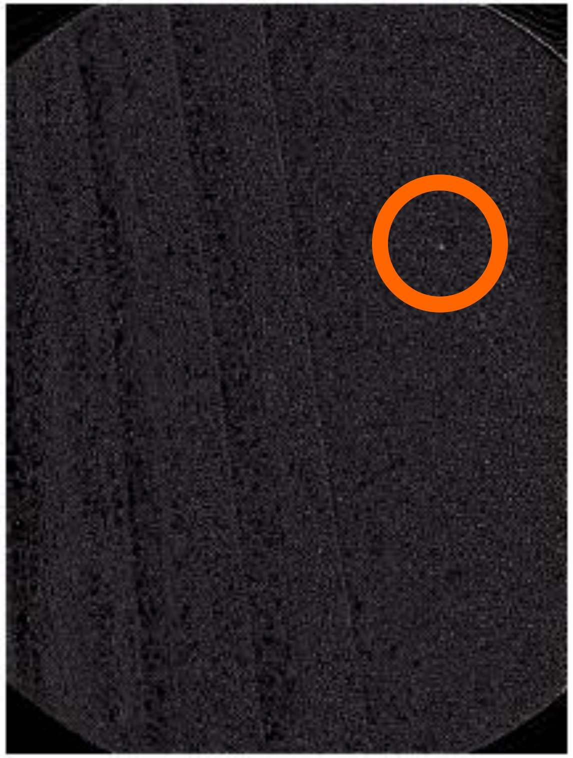
–1	–1	–1
–1	8	–1
–1	–1	–1

Points are detected at those pixels in the subsequent filtered image that are above a set threshold

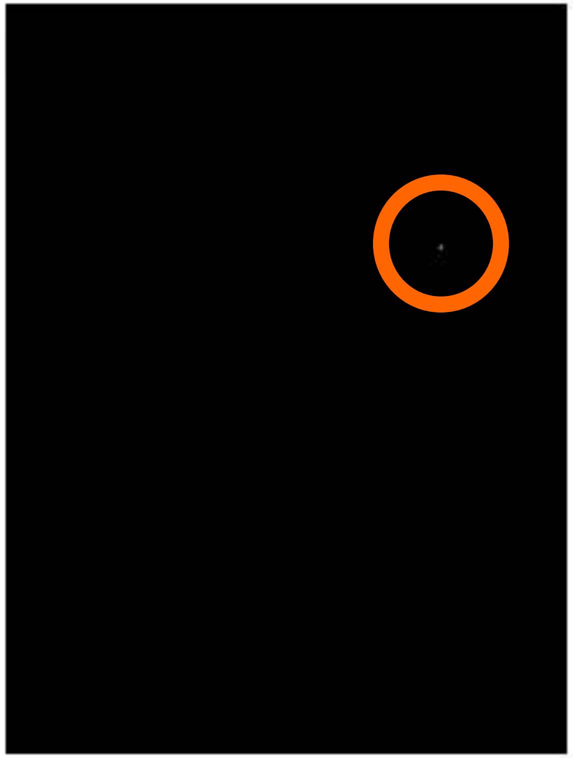
Point Detection (cont...)



X-ray image of
a turbine blade



Result of point
detection



Result of
thresholding

Line Detection

- The next level of complexity is to try to detect lines
- The masks below will extract lines that are one pixel thick and running in a particular direction

−1	−1	−1
2	2	2
−1	−1	−1

Horizontal

−1	−1	2
−1	2	−1
2	−1	−1

$+45°$

−1	2	−1
−1	2	−1
−1	2	−1

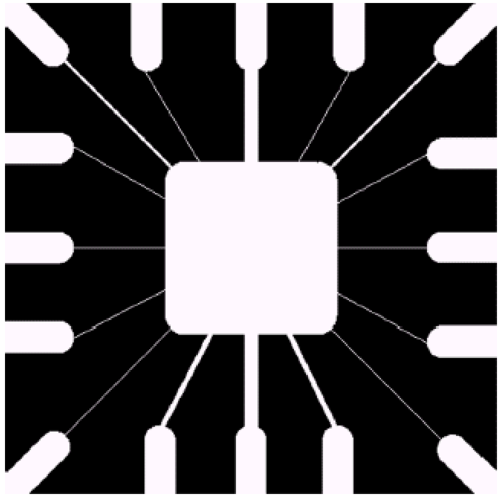
Vertical

2	−1	−1
−1	2	−1
−1	−1	2

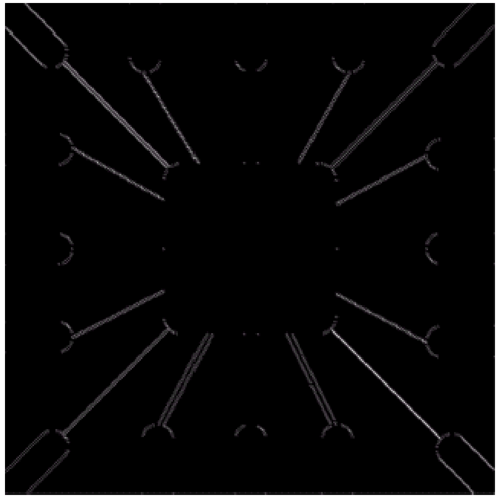
$-45°$

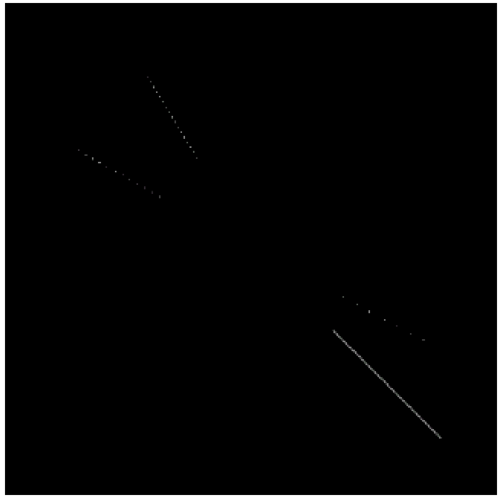
Line Detection (cont...)

Binary image of a wire bond mask



After processing with -45° line detector

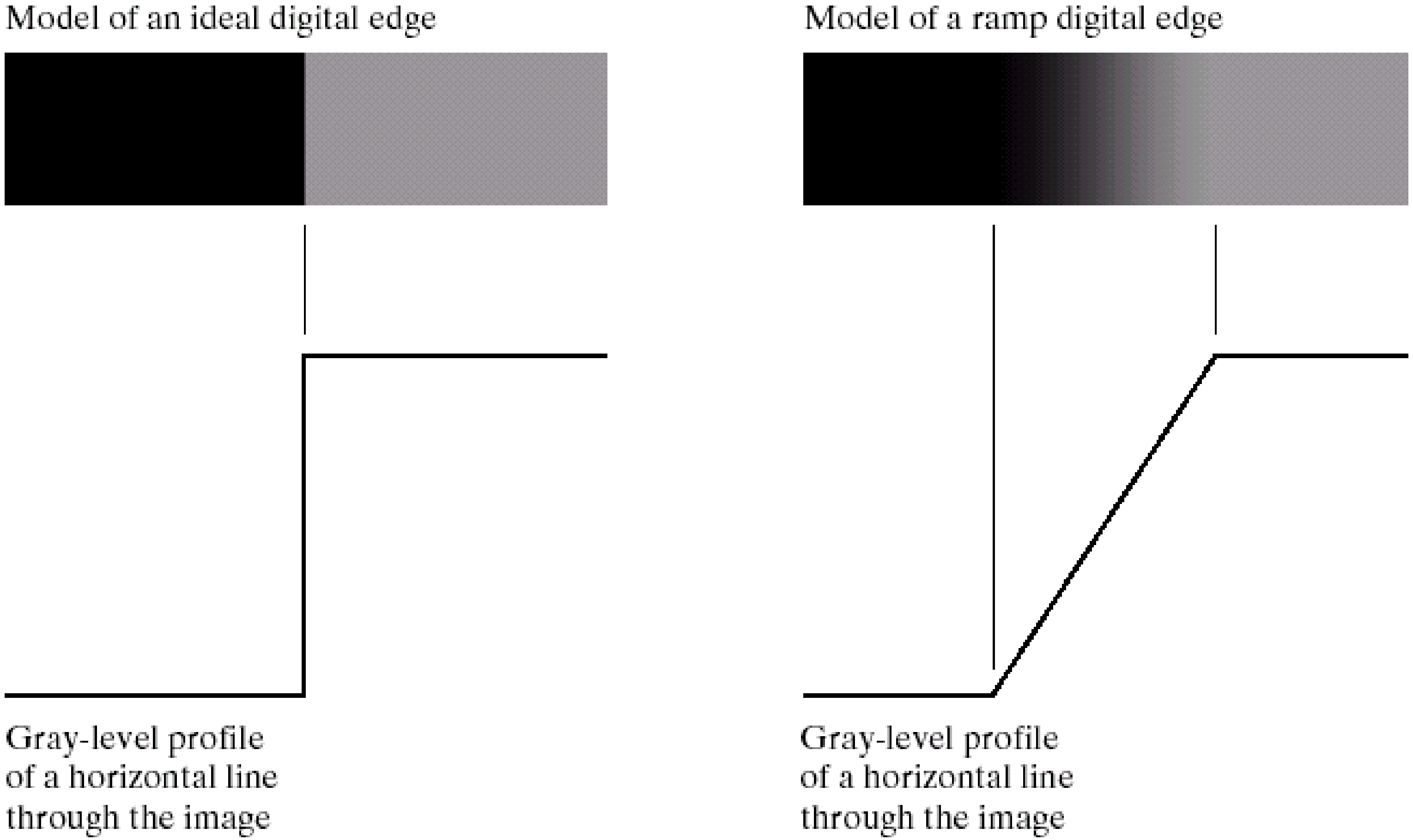




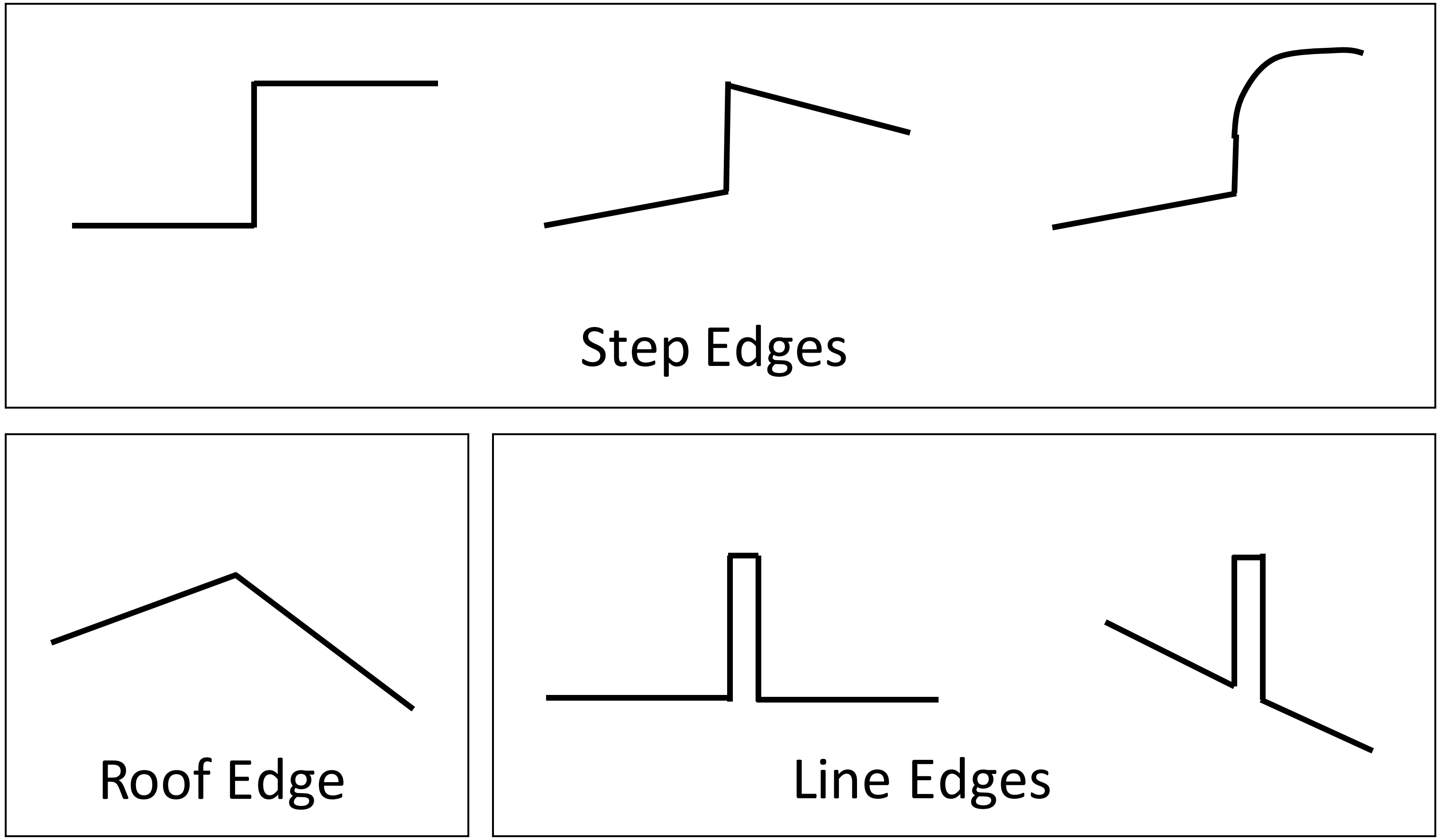
Result of thresholding filtering result

Edge Detection

- An edge is a set of connected pixels that lie on the boundary between two regions

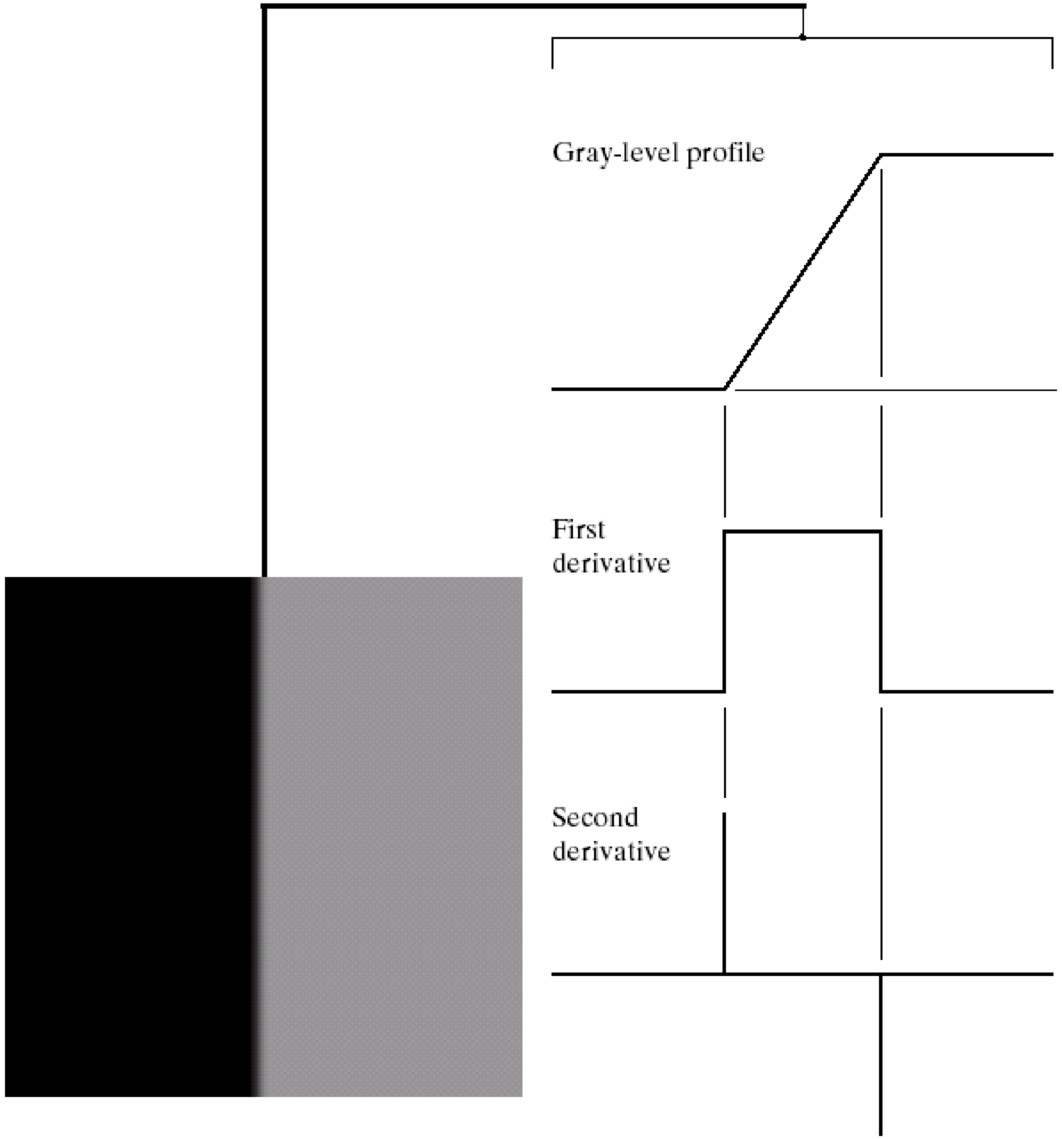


Edge Types



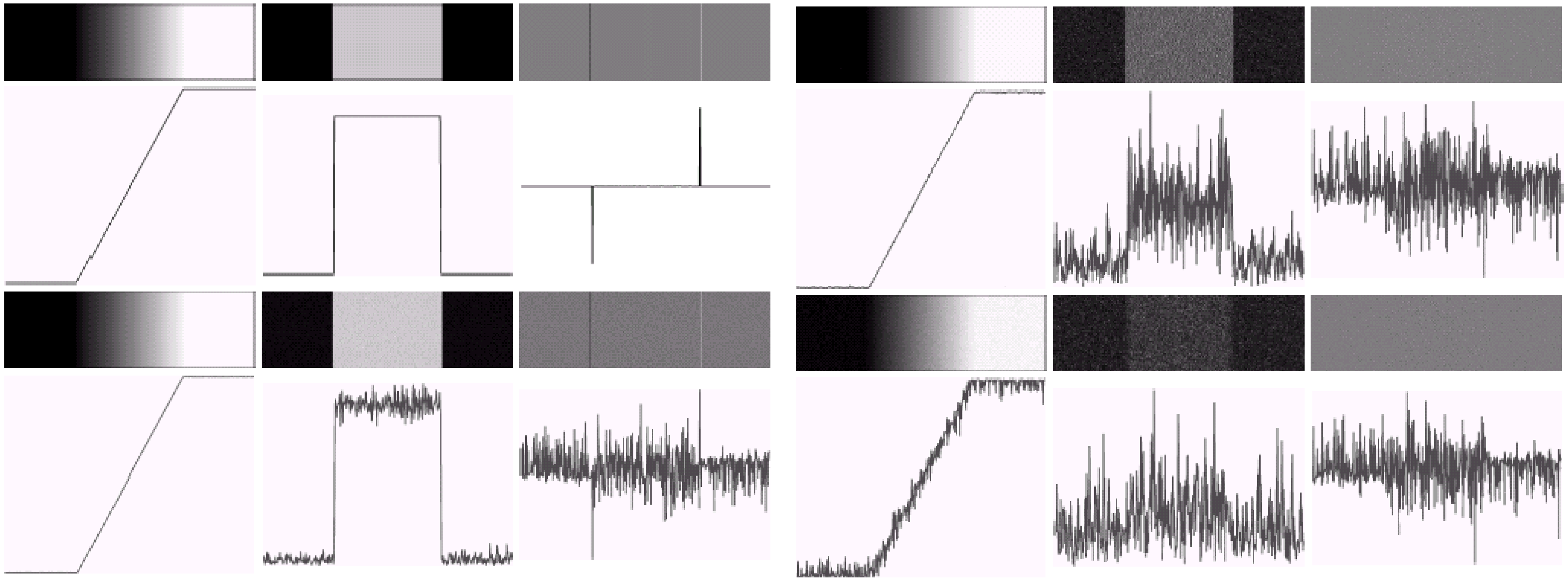
Edges & Derivatives

- We have already spoken about how derivatives are used to find discontinuities
- 1st derivative tells us ***where an edge is***
- 2nd derivative can be used to ***show edge direction***



Derivatives & Noise

- Derivative based edge detectors are extremely sensitive to noise
- We need to keep this in mind



Common Edge Detectors

- Given a 3*3 region of an image the following edge detection filters can be used

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

Prewitt

−1	0
0	1

0	−1
1	0

Roberts

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Sobel

Sobel Operator

- Looks for edges in both horizontal and vertical directions, then combine the information into a single metric.
- The masks are as follows:

$$y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \qquad x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Edge Magnitude $= \sqrt{x^2 + y^2}$ Edge Direction = $\tan^{-1}\left[\frac{y}{x}\right]$

Prewitt Operator

- Similar to the Sobel, with different mask coefficients:

$$y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \qquad x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

Edge Magnitude = $\sqrt{x^2 + y^2}$ Edge Direction = $\tan^{-1}\left[\frac{y}{x}\right]$

Edge Detection Example

Original Image

Horizontal Gradient Component

Vertical Gradient Component

Combined Edge Image

Edge Detection Example

Edge Detection Example

Edge Detection Example

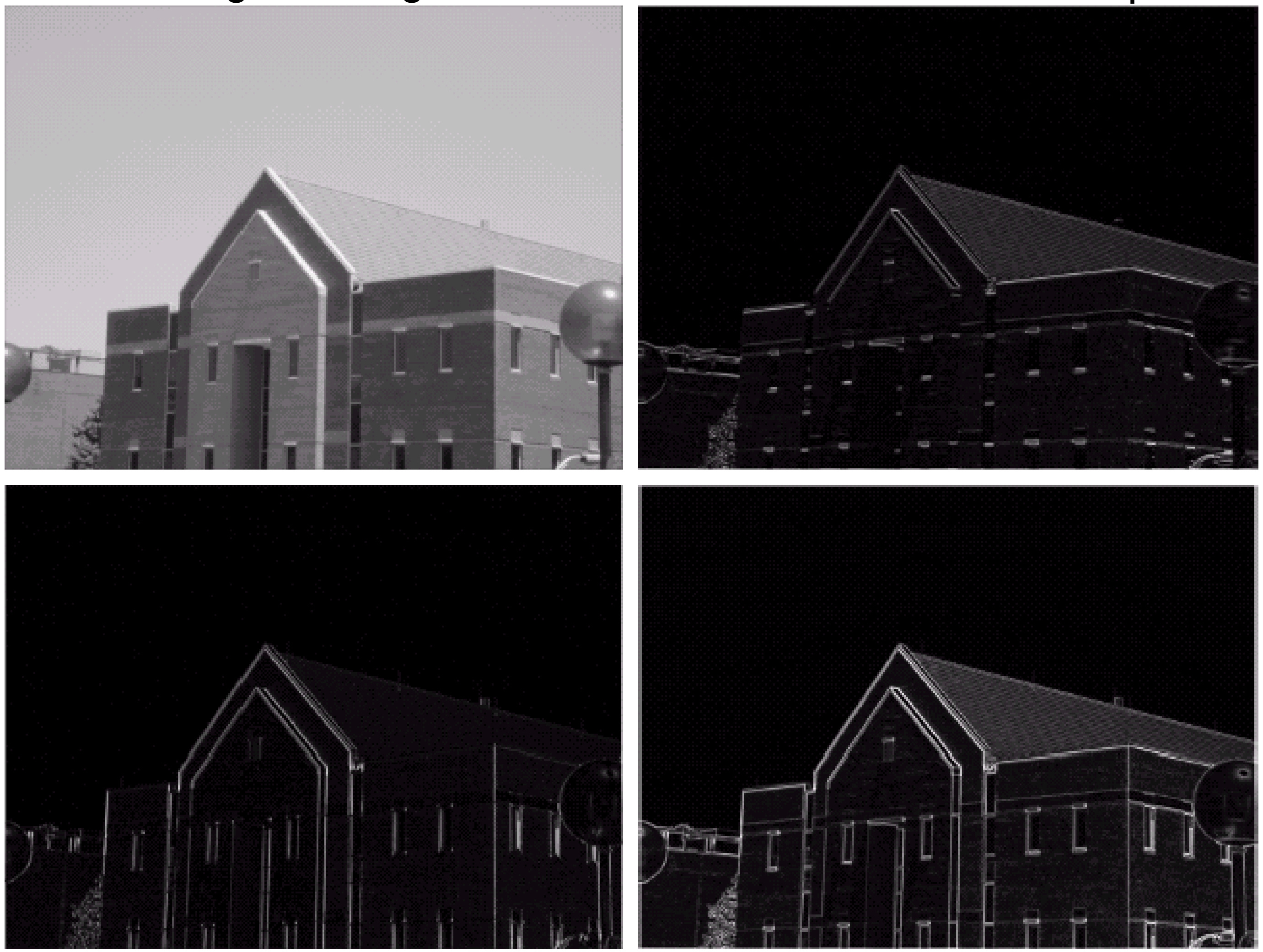
Edge Detection Example

Edge Detection Problems

- Often, problems arise in edge detection is that there are too much detail
- For example, the brickwork in the previous example
- One way to overcome this is to smooth images prior to edge detection

Edge Detection Example With Smoothing

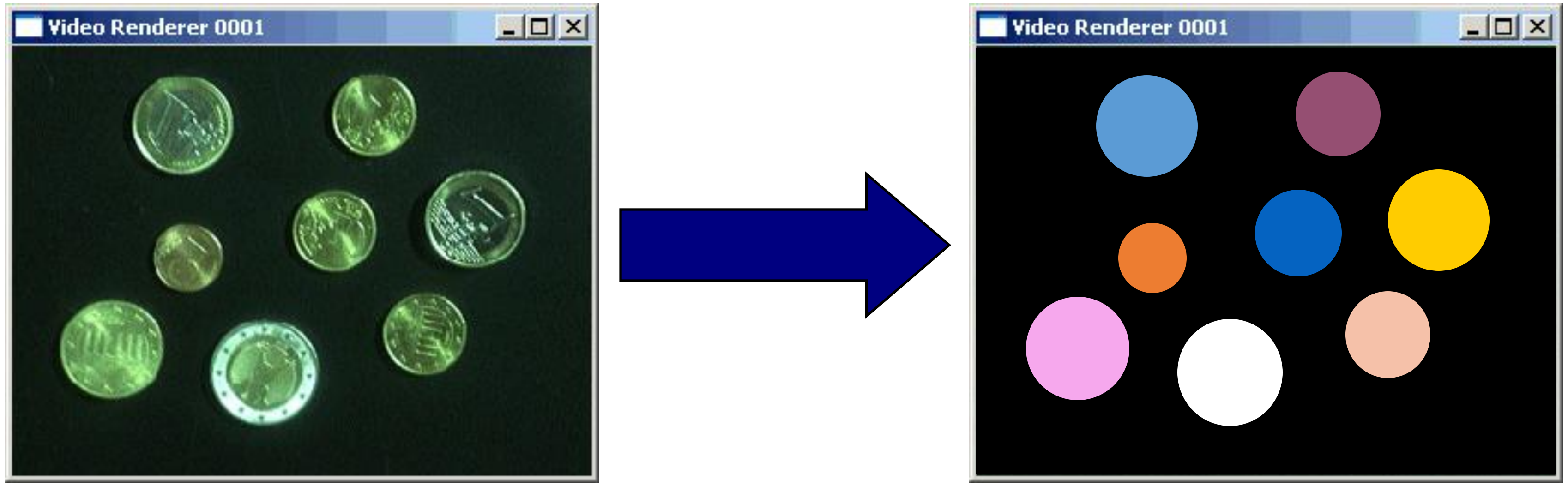
Original Image | Horizontal Gradient Component



Vertical Gradient Component | Combined Edge Image

Image Segmentation

- Click here



Similar-based approach

- Thresholding in color image
- In the case of color images the feature vector x can be three RGB image components {IR(r,c),IG(r,c),IB(r,c)
- A simple segmentation rule may have the form:

P(R,x,t) : (IR(r,c) <T(R)) && (IG(r,c)<T(G))&&

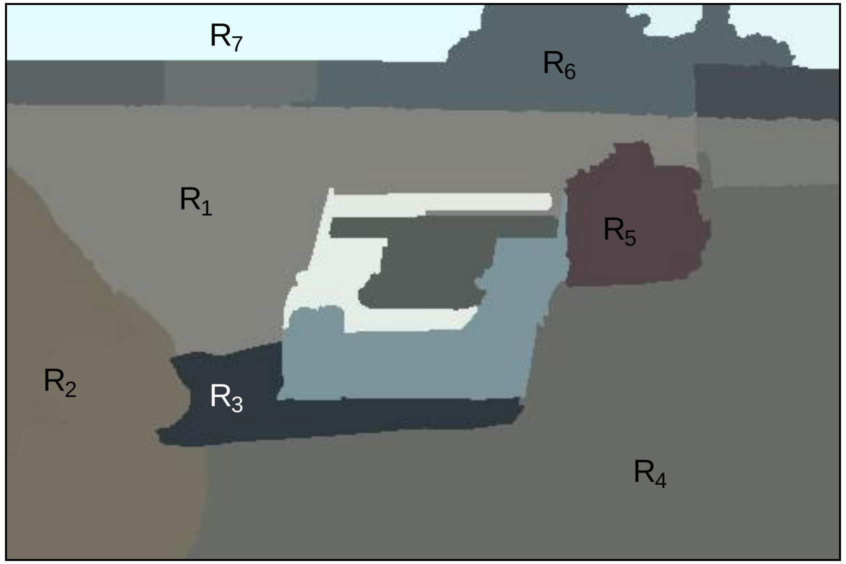
(IB(r,c) < T(B))

Why Region-Based Segmentation?

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

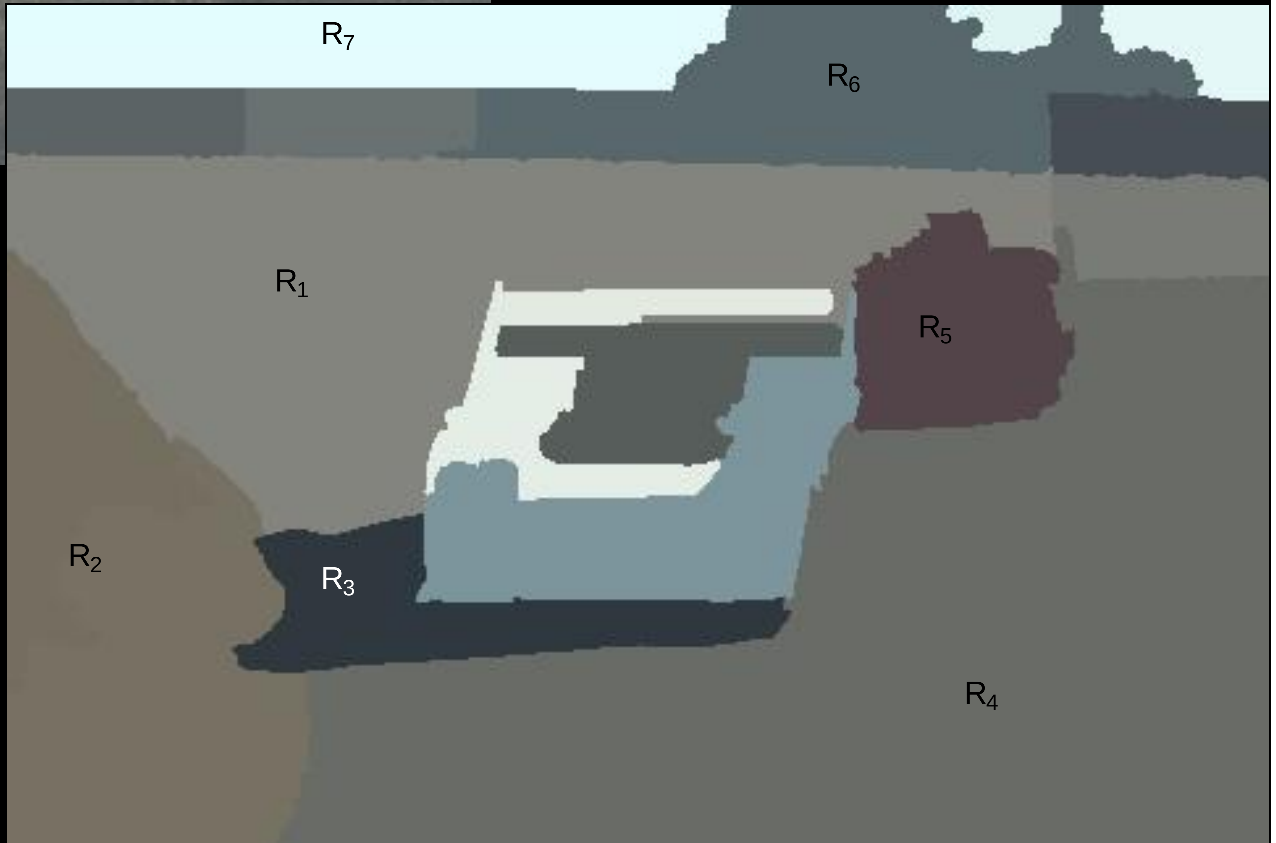
Definitions

- 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.



$$R_i \bigcap R_j = \varnothing$$

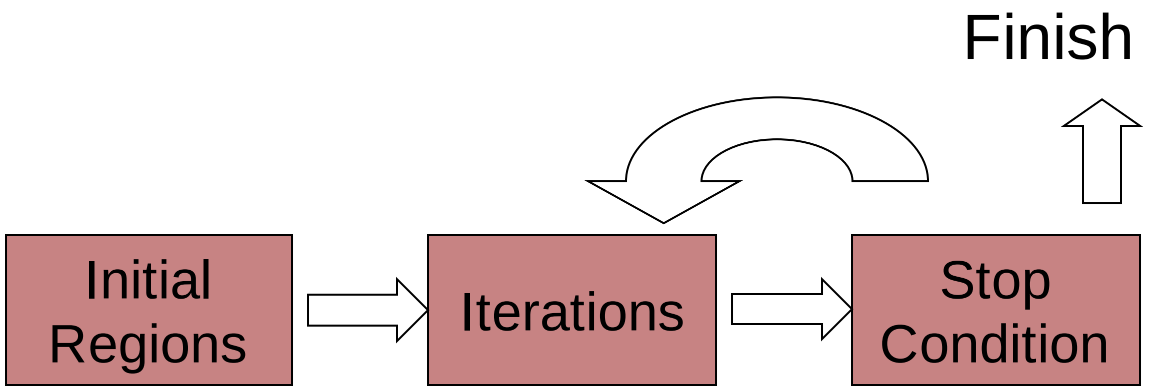

ASTROL
CASTROL
Castrol
96
33

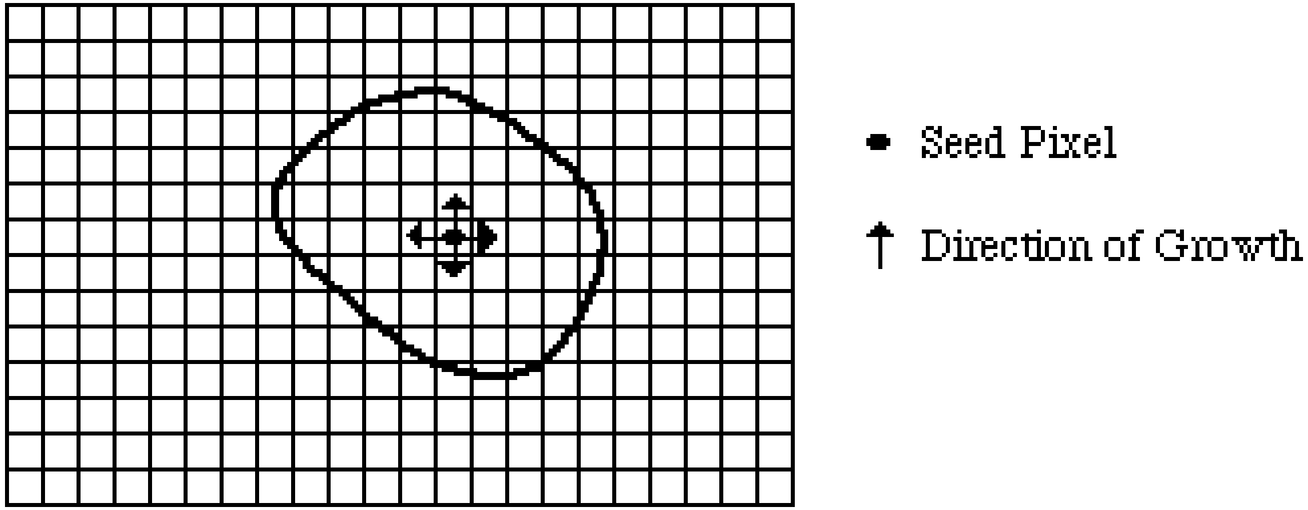

R_7
R_6
R_1
R_5
R_2
R_3
R_4

Region growing

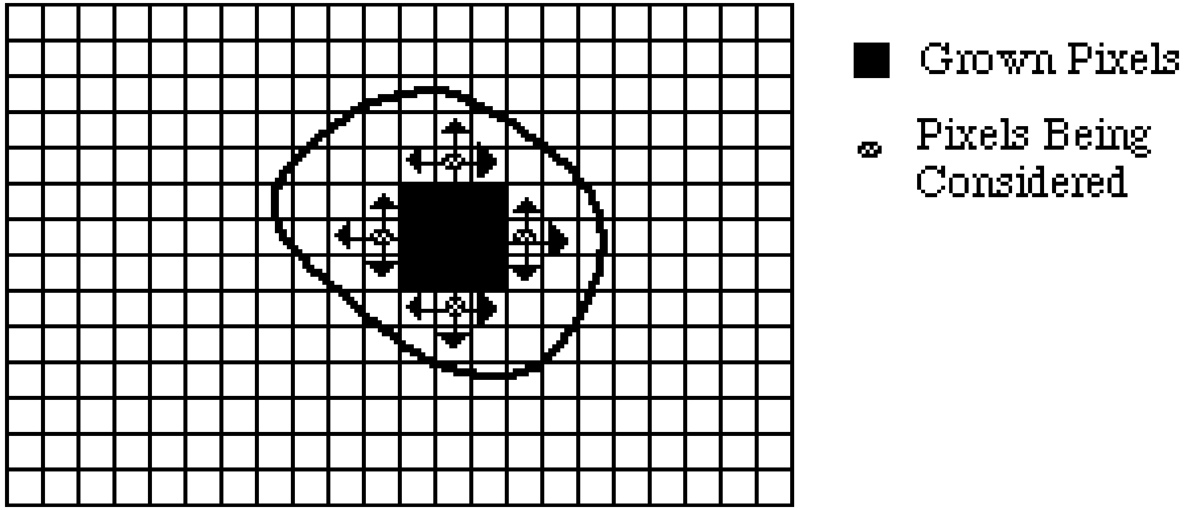
- Groups pixels into larger regions.
- Starts with a **seed** region.
- **Grows** region by **merging** neighboring pixels.

- Iterative process
  - How to start?
  - How to iterate?
  - When to stop?





(a) Start of Growing a Region



(b) Growing Process After a Few Iterations

Thank You