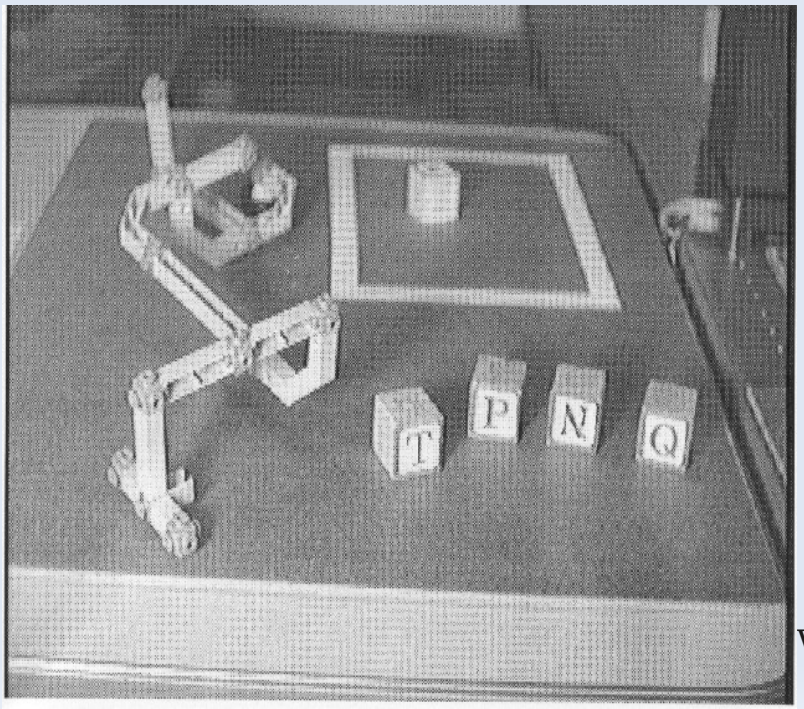
Edge Detection

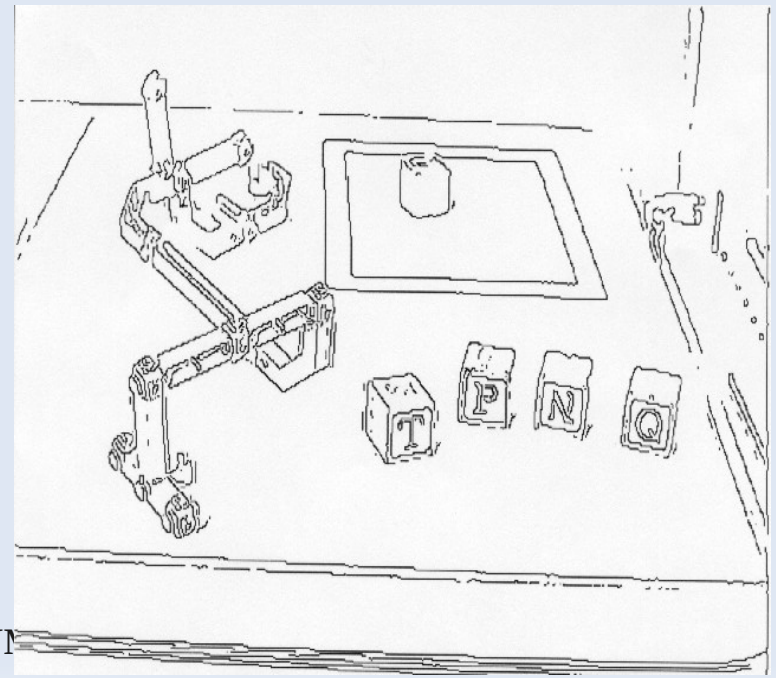
Edge Detection

- Applications
- Edge Detection Basics
- Some Advanced Techniques

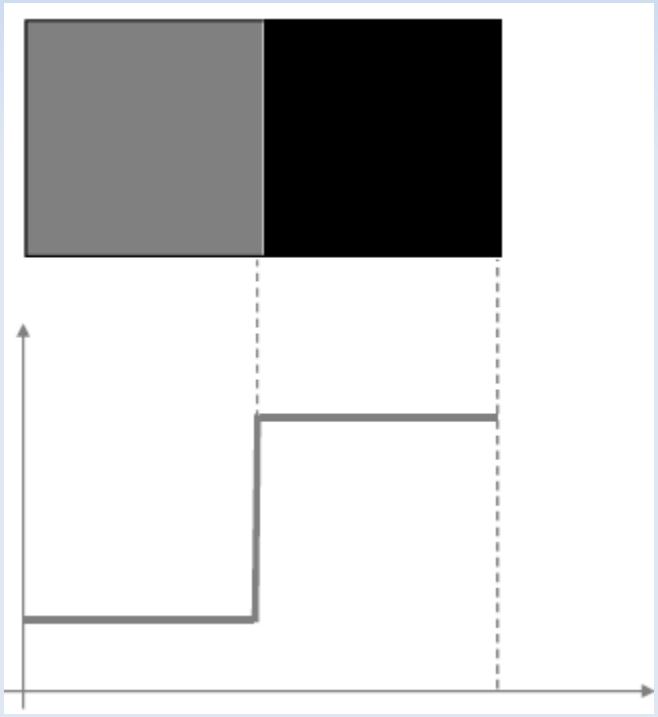
Applications

- Produce a line drawing of a scene from an image of that scene
- Important features (e.g., corners,lines, curves)
- These features are used by higher-level computer vision algorithms (e.g., recognition)

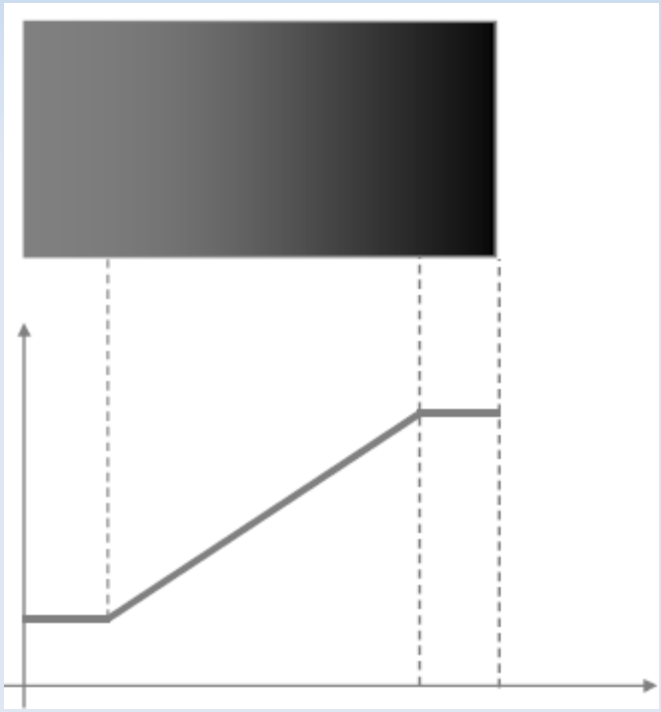




Gray-Level Transition

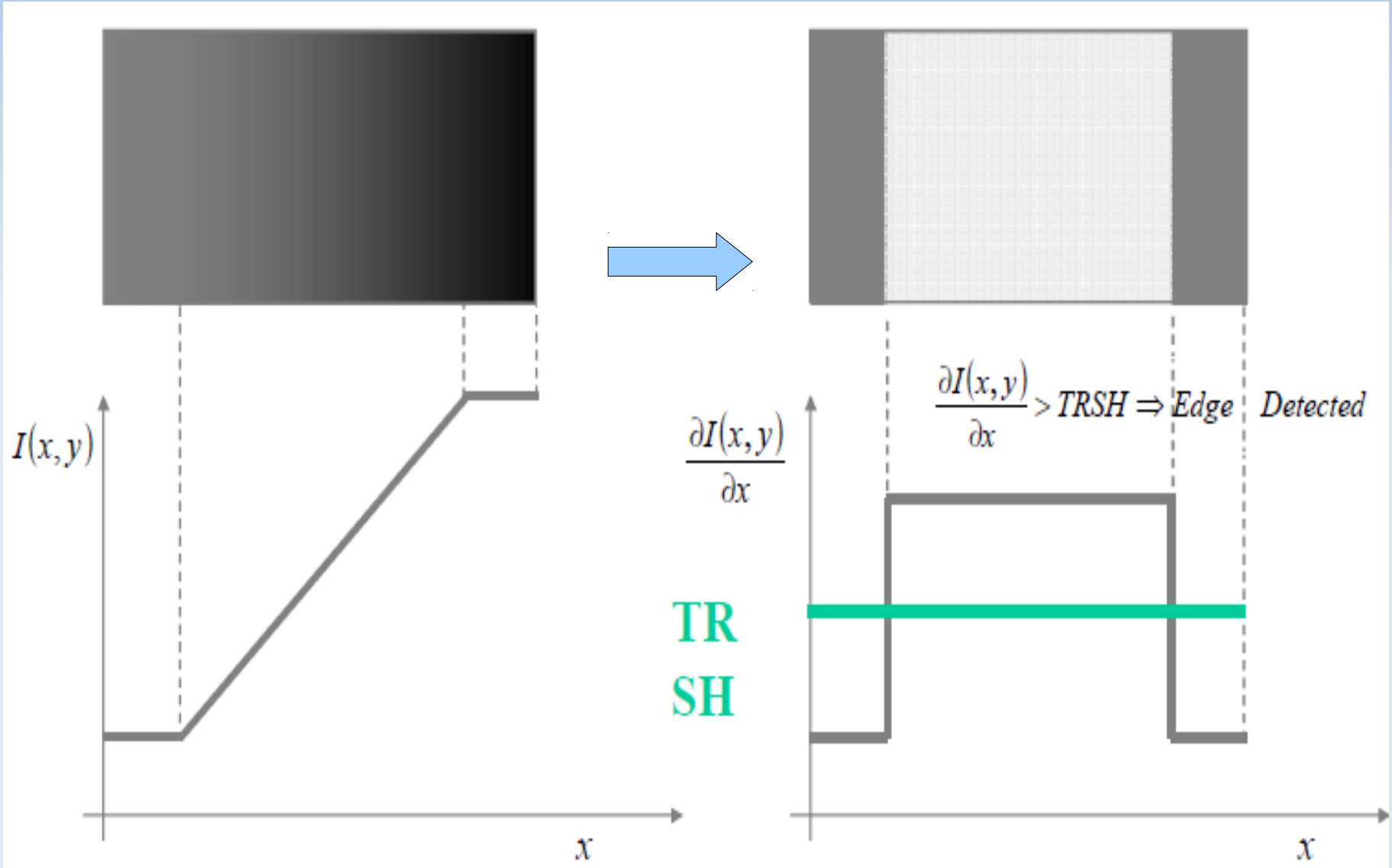


Sharp Edge



Smooth Edge

Detecting the edges



Derivative (w.r.t images)

- First Order Derivative

$$f'(x) = \lim_{h->0} \frac{f(x+h) - f(x)}{h} \approx f(x+1) - f(x)$$

- Second Order Derivative

$$f''(x) = \lim_{h->0} \frac{f'(x+h) - f'(x)}{h} \approx f'(x+1) - f'(x) =$$

$$f(x+2) - 2f(x+1) + f(x) \quad (h=1)$$

Derivative (w.r.t images)

- First Order Derivative

$$\frac{\partial f}{\partial x} = \frac{f(x+h_x, y) - f(x,y)}{h_y} = f(x+1, y) - f(x,y), \quad (h_x=1)$$

$$\frac{\partial f}{\partial y} = \frac{f(x, y+h_y) - f(x,y)}{h_y} = f(x, y+1) - f(x,y), \quad (h_y=1)$$

- Second Order Derivative

$$f''(x) = \lim_{h->0} \frac{f'(x+h) - f'(x)}{h} \approx f'(x+1) - f'(x) =$$

$$f(x+2) - 2f(x+1) + f(x) \quad (h=1)$$

Laplacian (Second Derivative)

- Laplacian-

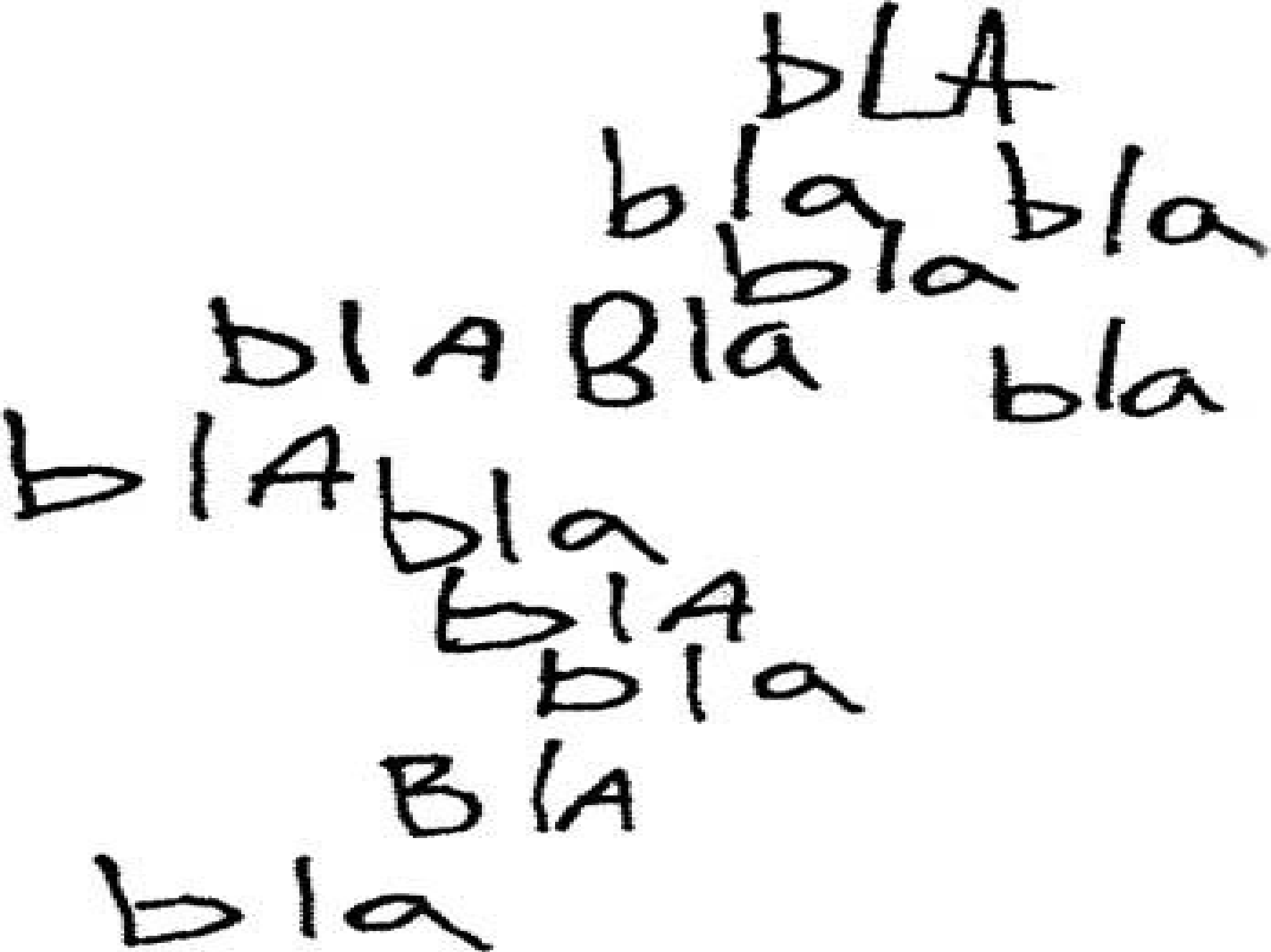
$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

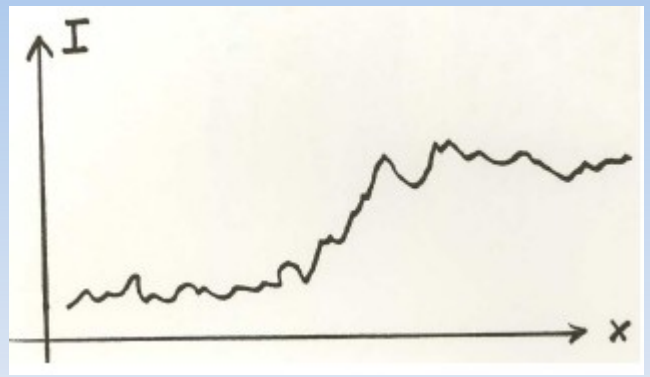
- In case of images !!

$$\frac{\partial^2 f}{\partial x^2} = f(i, j+1) - 2f(i, j) + f(i, j-1)$$

$$\frac{\partial^2 f}{\partial y^2} = f(i+1, j) - 2f(i, j) + f(i-1, j)$$

$$\nabla^2 f = -4f(i, j) + f(i, j+1) + f(i, j-1) + f(i+1, j) + f(i-1, j)$$


bLA
bla bla
bla
bla Bla bla
bla
bla bla
bla
bla
Bla
bla



Noisy and discrete :P

An edge oprator capable of finding-

- Edge Magnitude
- Edge Direction
- High Detection Rate and good localization

Gradient Operator

- The gradient of the image I(x,y) at location (x,y), is the vector-

$$\overline{\nabla I} = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial I(x,y)}{\partial x} \\ \frac{\partial I(x,y)}{\partial y} \end{bmatrix}$$

- The magnitude of the gradient-

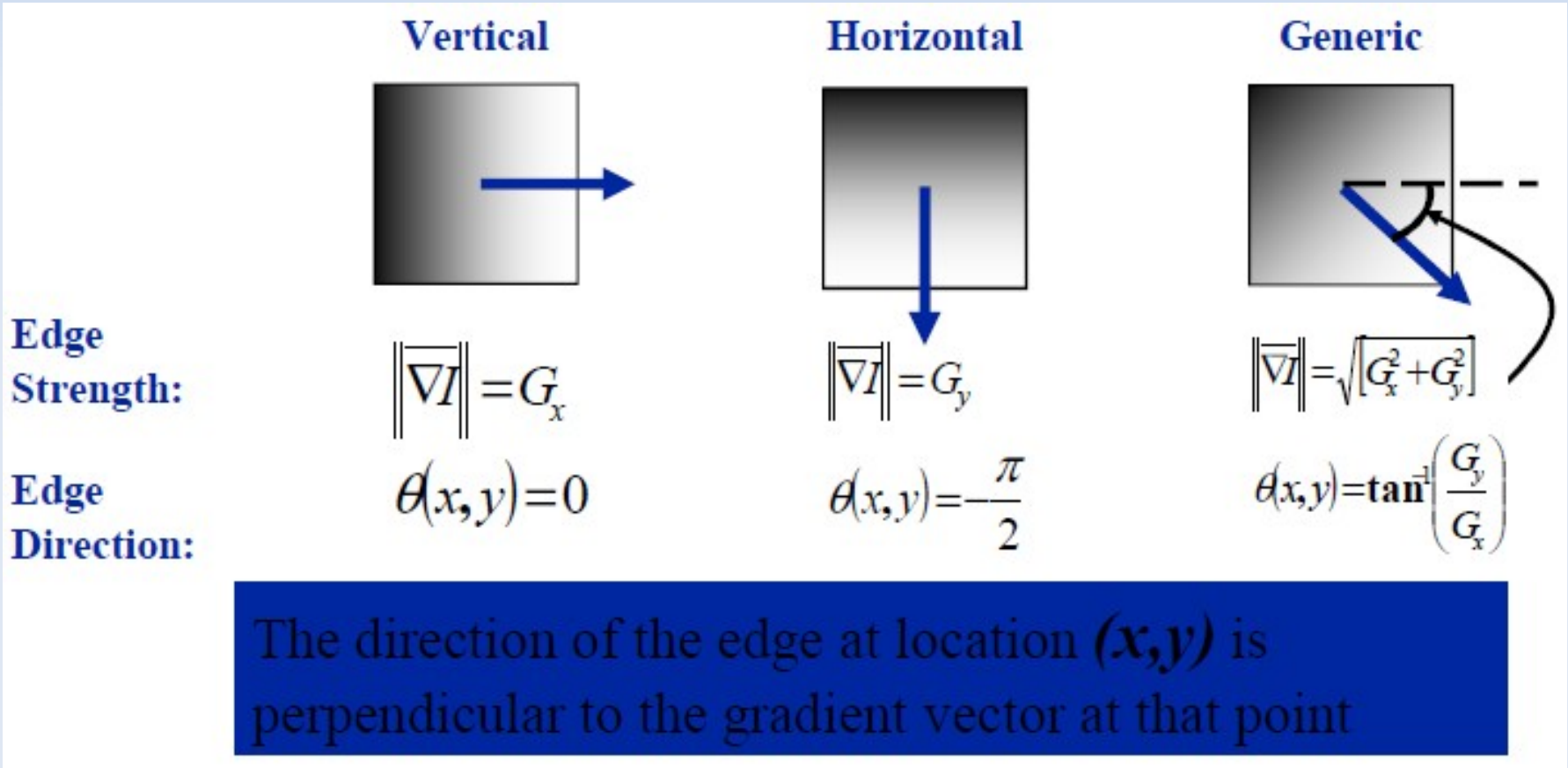
$$|G| = \sqrt{Gx^2 + Gy^2} \qquad |G| = |Gx| + |Gy|$$

- The direction of the gradient vector-

$$\theta = \arctan(Gy/Gx)$$

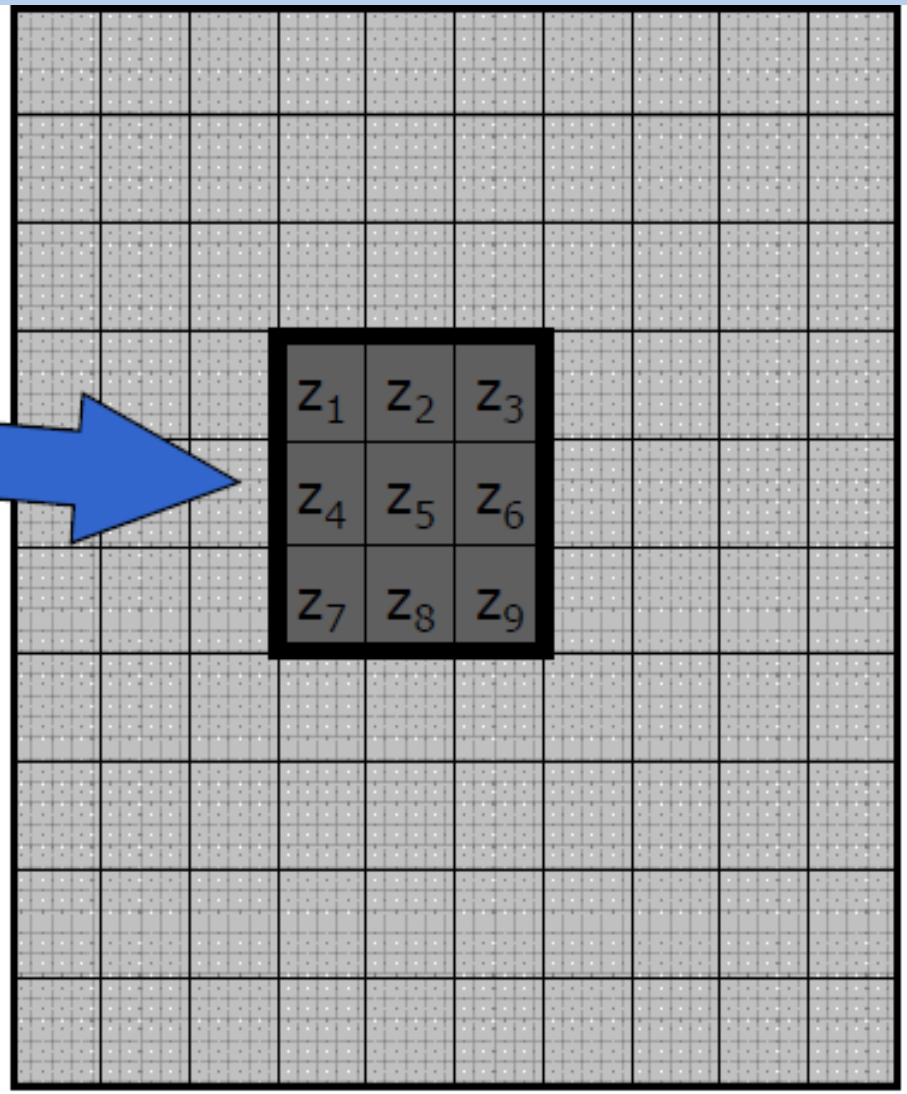
The Meaning of the Gradient

- Represents the direction of the strongest variation in intensity



Calculating the Gradient

For each pixel the gradient is calculated, based on a 3x3 neighborhood around this pixel.



EDGE DETECTION TECHNIQUES

Robert's Operator

0	0	0
0	-1	0
0	0	1

$$G_x \approx z_9 - z_5$$

0	0	0
0	0	-1
0	1	0

$$G_y \approx z_8 - z_6$$

- designed to respond maximally to edges running at 45° to the pixel grid

Prewitt Edge Detector

-1	-1	-1
0	0	0
1	1	1

$$G_x \approx (z_7 + z_8 + z_9) - (z_1 + z_2 + z_3)$$

-1	0	1
-1	0	1
-1	0	1

$$G_y \approx (z_3 + z_6 + z_9) - (z_1 + z_4 + z_7)$$

- respond maximally to edges running vertically and horizontally relative to the pixel grid

Sobel Operator

-1	-2	-1
0	0	0
1	2	1

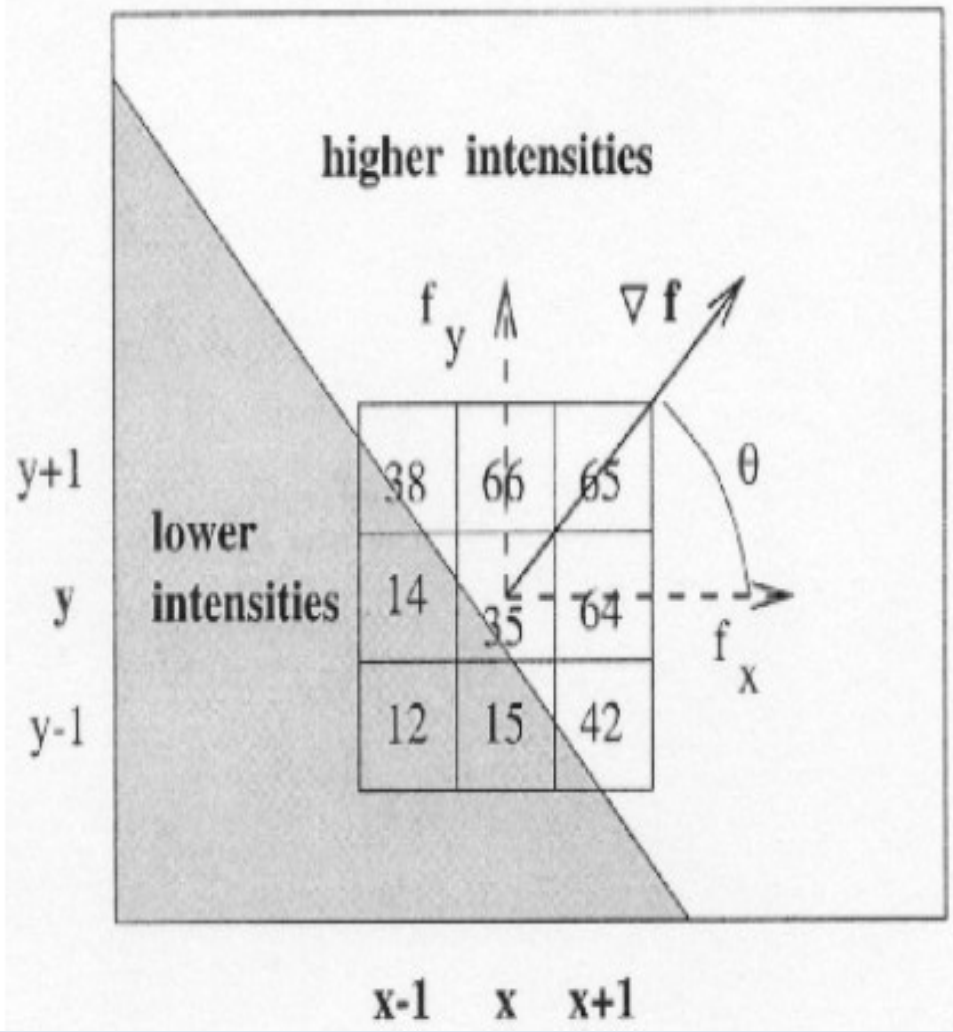
$$G_x \approx (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

-1	0	1
-2	0	2
-1	0	1

$$G_y \approx (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$

- respond maximally to edges running vertically and horizontally relative to the pixel grid (also gives a smothing effect- forget how .. :P)

Lets do an example



$$f_y = ((38-12)/2 + (66-15)/2 + (65-42)/2) / 3 = (13 + 25 + 11) / 3 = 16$$

$$f_x = ((65-38)/2 + (64-14)/2 + (42-12)/2) / 3 = (13 + 25 + 15) / 3 = 18$$

$$\theta = \tan^{-1} (16 / 18) = 0.727 \text{ rad} = 42 \text{ degrees}$$

$$|\nabla f| = (16^2 + 18^2)^{1/2} = 24$$

Comparing Edge Operators

Roberts (2 x 2):

0	1
-1	0

1	0
0	-1

Sobel (3 x 3):

-1	0	1
-1	0	1
-1	0	1

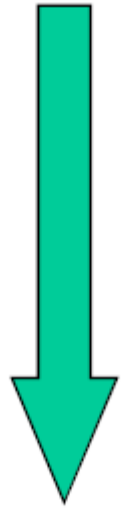
1	1	1
0	0	0
-1	-1	1

Sobel (5 x 5):

-1	-2	0	2	1
-2	-3	0	3	2
-3	-5	0	5	3
-2	-3	0	3	2
-1	-2	0	2	1

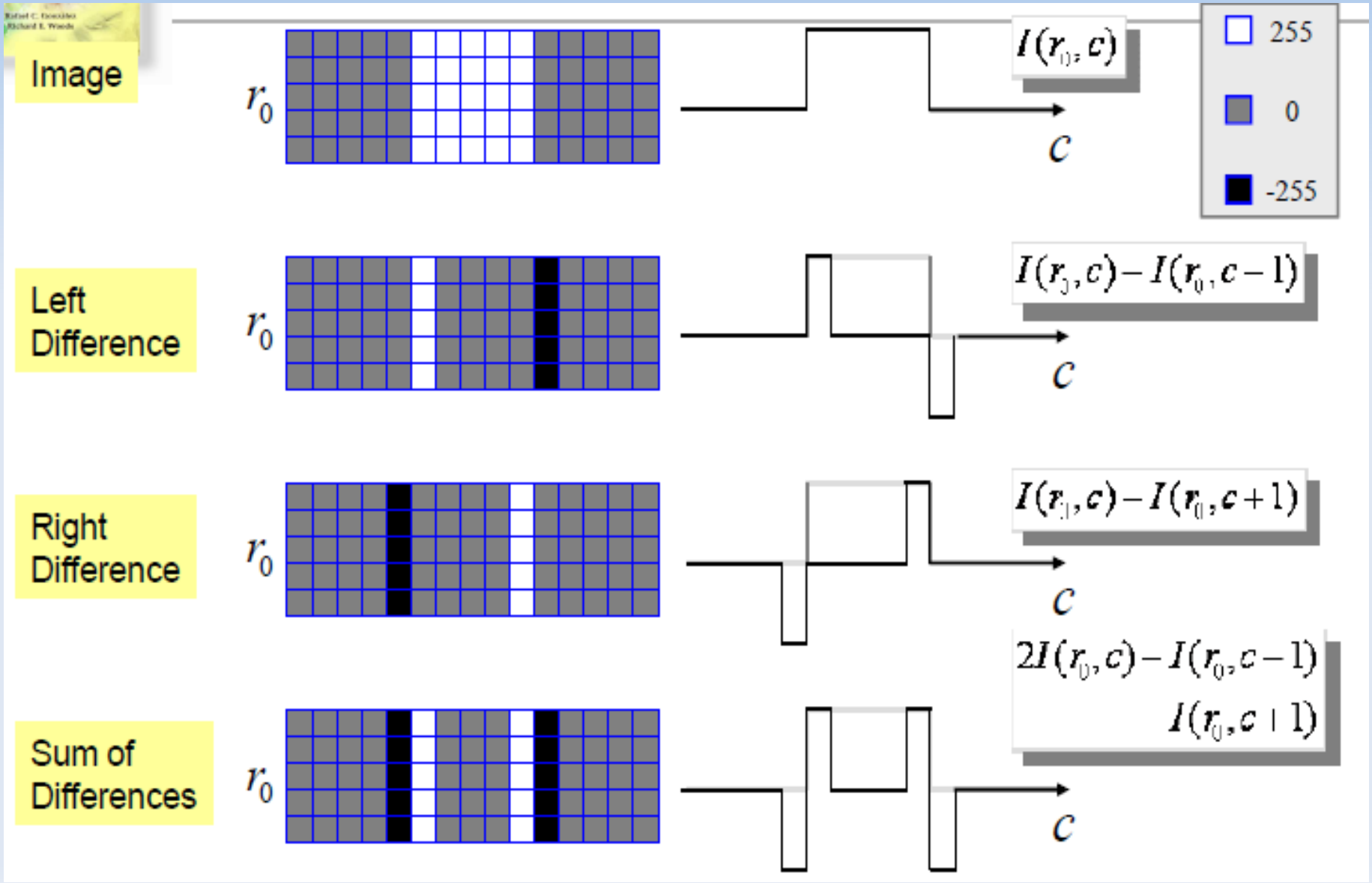
1	2	3	2	1
2	3	5	3	2
0	0	0	0	0
-2	-3	-5	-3	-2
-1	-2	-3	-2	-1

Good Localization
Noise Sensitive
Poor Detection

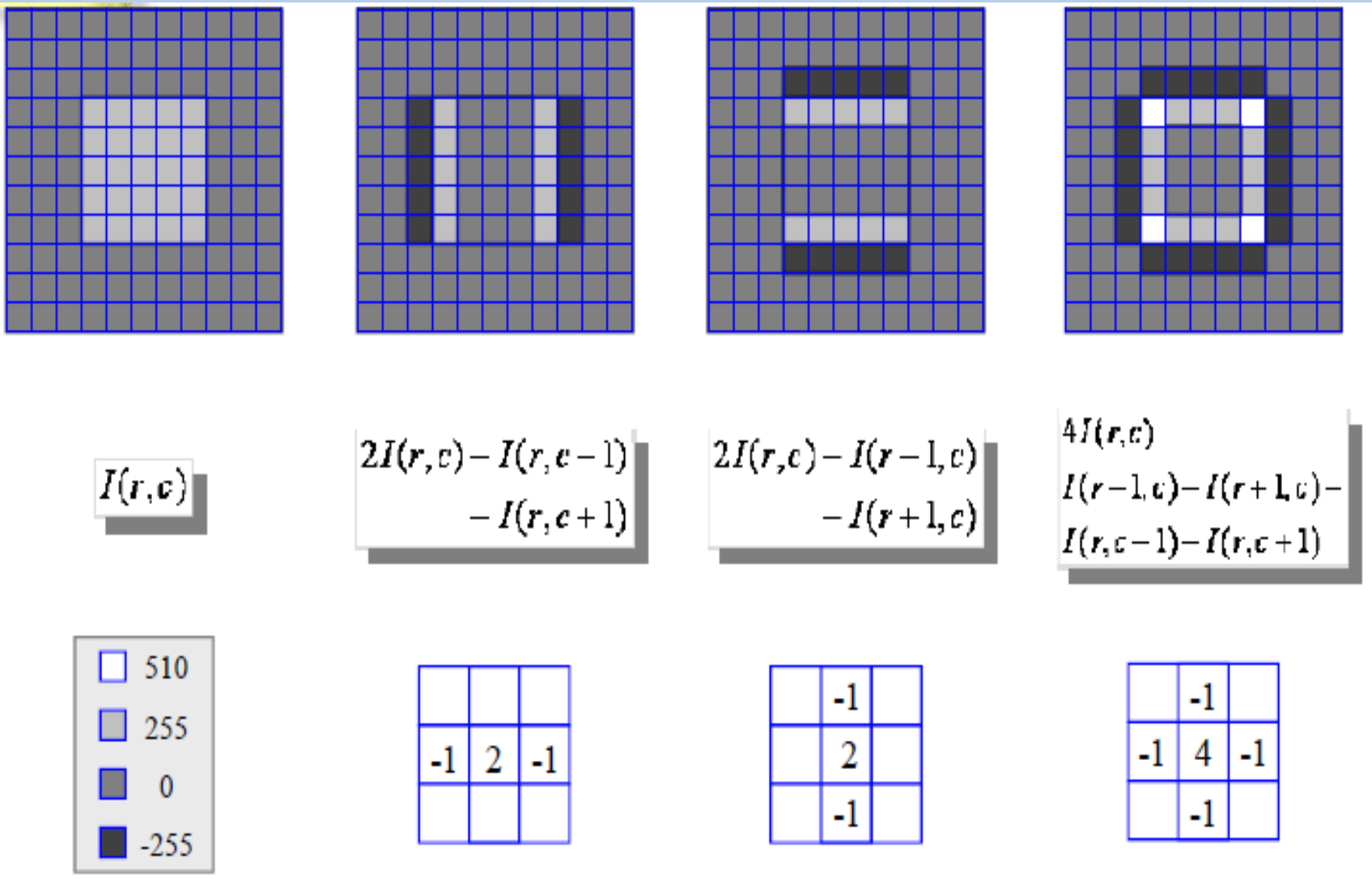


Poor Localization
Less Noise Sensitive
Good Detection

Vertical Edge Detection



Symmetric Edge Detection



Detection of Isolated Points

Detection of Isolated Points

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

Comparison of Edge detection Algorithm

Original

Sobel

Prewitt

Robert

Doubts ??