Edge

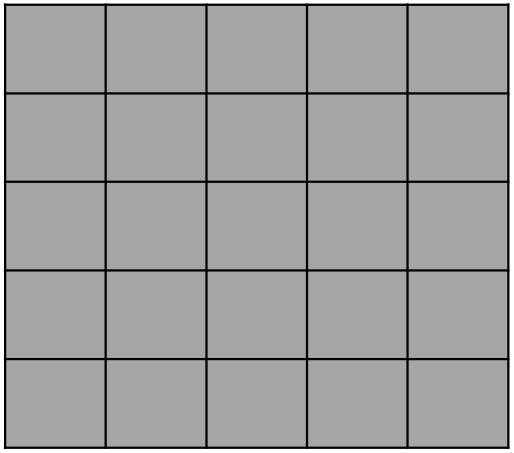
이진영

Edge

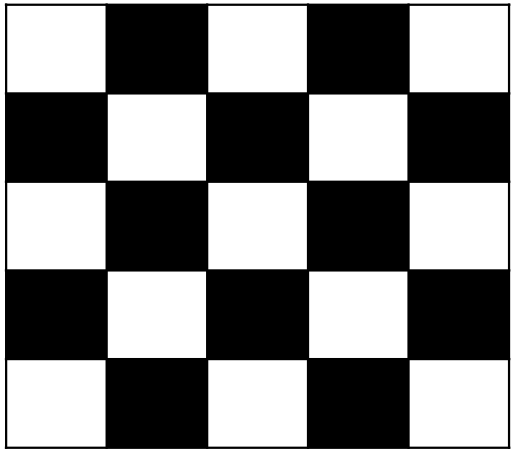
- Significant or sudden changes of intensity in an image
- Points that image intensity has discontinuities
- Boundary between two different regions, such as object and background
- Important features in image processing and computer vision fields

Image Characteristics

- Generally, many edges in complicated images, but no edge in homogeneous images



Homogeneous



Complicated

Pixel Difference

- Edge, if difference between two pixel values > threshold (Otherwise, no edge)

101	102	103	100	100	100	100	100
104	50	103	100	100	100	100	100
100	100	105	110	100	100	100	100
100	110	100	100	100	100	100	100
130	140	100	100	100	100	111	100
150	135	255	255	100	100	109	107
100	120	255	255	255	100	100	101
110	100	220	255	255	255	255	100

Diff > 15

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
255	255	0	0	0	0	0	0
255	255	255	255	0	0	0	0
255	255	255	255	255	0	0	0
255	255	255	0	255	255	255	0
0	255	255	255	255	255	255	255

Edge

Edge Detection

- Image processing of finding discontinuities of image brightness
- Generally, detection based on calculation of gradient magnitude

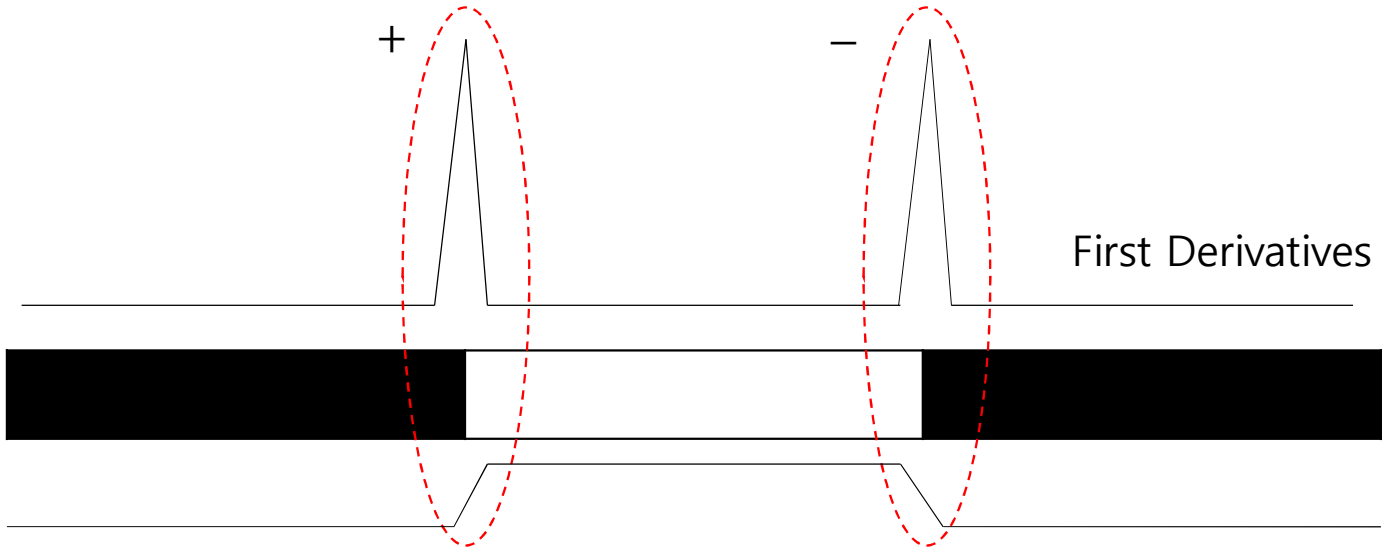
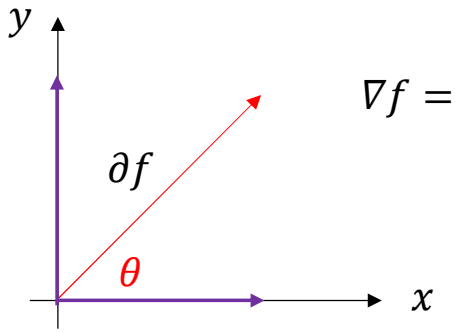


Image Gradient

- Gradient using two partial derivatives



$$\nabla f = [G_x, G_y] = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$$

- Gradient direction

$$\theta = \tan^{-1}\left(\frac{G_y}{G_x}\right) = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$$

- Gradient magnitude

$$||\nabla f|| = \sqrt{G_x^2 + G_y^2} = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

$$\approx |G_x| + |G_y|$$

Approximation of Derivative

- Derivative using forward, backward, and central differences

Forward $$f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

Backward $$f'(x) = \lim_{h \to 0} \frac{f(x) - f(x-h)}{h}$$

Central $$f'(x) = \lim_{h \to 0} \frac{f(x+0.5 \cdot h) - f(x-0.5 \cdot h)}{h}$$

First Derivative of Discrete Signal

- Forward, backward, and central differences using two or three consecutive points

Forward $$f'(x_0) = \frac{f(x_1) - f(x_0)}{x_1 - x_0}$$

0	-1	1

Backward $$f'(x_0) = \frac{f(x_0) - f(x_{-1})}{x_0 - x_{-1}}$$

-1	1	0

Central $$f'(x_0) = \frac{f(x_1) - f(x_{-1})}{x_1 - x_{-1}}$$

-1	0	1

Derivative Filter

- Two filters for horizontal and vertical gradients
  - Partial derivative of an image with respect to its x (G_x)
  - Partial derivative of an image with respect to its y (G_y)

-1	0	1

-1
0
1

Derivative Filters

Simple Edge Detection

- Calculation of gradient vectors at each pixel through horizontal and vertical derivative filters

$$\nabla f = [G_x, G_y] = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$$

- Calculation of a gradient magnitude at each pixel

$$||\nabla f|| = \sqrt{G_x^2 + G_y^2} = \sqrt{(\frac{\partial f}{\partial x})^2 + (\frac{\partial f}{\partial y})^2}$$

-1	0	1

-1
0
1

- Determination of edge pixels, based on a threshold

$$||\nabla f|| \geq Thd$$

Experiment

- G_x and G_y representing horizontal and vertical gradients, respectively
- Edge image combining G_x and G_y (Gradient magnitude)

AICenterY.bmp

G_x Image

G_y Image

Edge Image

```
double G = sqrt(Gx * Gx + Gy * Gy);
Y3[j * width + i] = (unsigned char)(G > 255 ? 255 : (G < 0 ? 0 : G));
```