EDGE-BASED SEGMENTATION

EDGE IMAGE THRESHOLDING

- Gradient operators (Roberts, Prewitt and Sobel) are used for edge enhancement of an image.
- Results obtained by gradient operators along with

thresholding can be used to identify the border of an image.

- Two problems can occur:-

These methods along with thresholding will broaden the edge of an image thus affecting the accurate location of the edge.

Any edges retrieved can be easily corrupted by noise. [2]

- Canny proposed a method which solves the above two problems. It involves two steps:-

i. First, the image is smoothed by means of a Gaussian filter in order to reduce the effect of noise.

ii. Second, the gradient direction of the gradient image is processed with the non-maximal suppression method and is used for edge thinning.

- Given the original image $f(i, j)$, $0 \leq i \leq m - 1$, $0 \leq j \leq n - 1$, and by using the notation for neighbouring pixels shown in Figure below, the process of Canny's edge detection algorithm consists of the following four steps

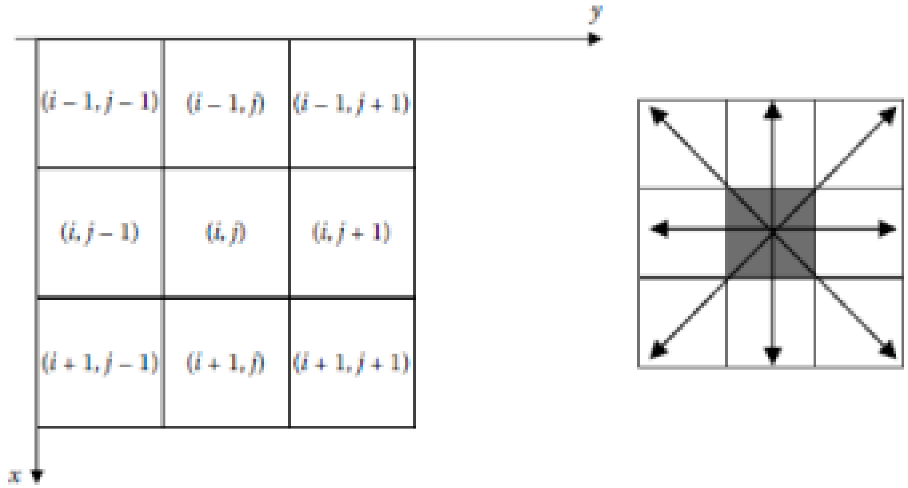
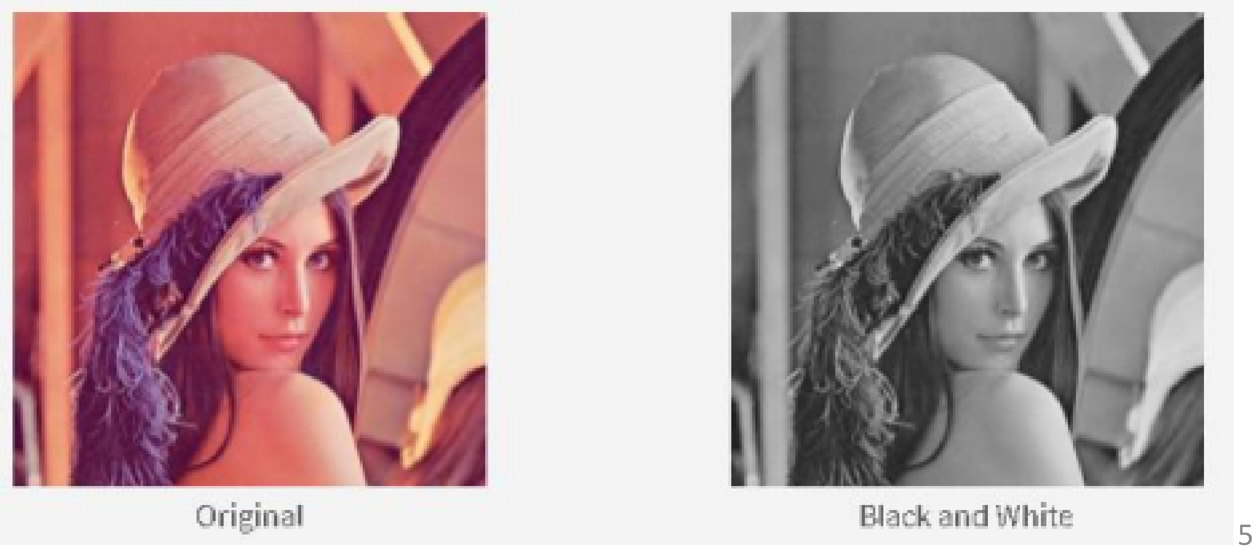


Figure 1: The neighbourhood of the pixel at point and the gradient directions.



Original　　　　　　Black and White

1. Use a Gaussian filter h to smooth the image f leading to the smoothed result S= h*f. The template of the Gaussian smoothing function h is used.

2. Compute the gradient magnitude G(i, j) and the gradient direction θ (i, j) of the pixel at point (i, j) of the image function S by using the formula

$$G(i,j)=\sqrt{(\frac{\partial S}{\partial x}(i,j))^2+(\frac{\partial S}{\partial y}(i,j))^2}$$

$$\theta(i,j)=\arctan\left(\frac{\frac{\partial S}{\partial y}(i,j)}{\frac{\partial S}{\partial x}(i,j)}\right)$$

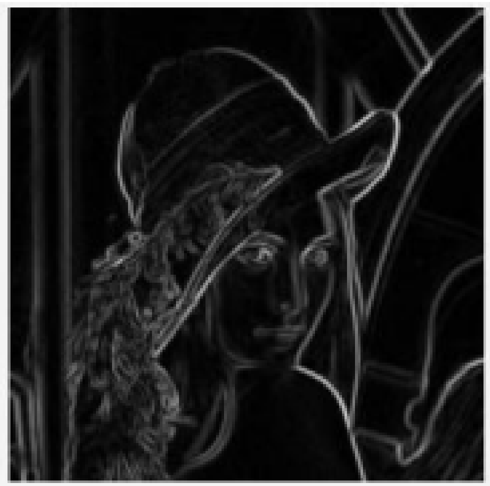
where the approximate discrete formula of the two partial derivatives are given by

$$\frac{\partial S}{\partial x}(i,j)=\frac{1}{2}[S(i+1,j)-S(i,j)+S(i+1,j+1)-S(i,j+1)]$$

$$\frac{\partial S}{\partial y}(i,j)=\frac{1}{2}[S(i,j+1)-S(i,j)+S(i+1,j+1)-S(i+1,j)]$$

Gx

Gy



Gradient Magnitude

3. The image magnitude produces results in thick edges.

Final image must have thin edges so we perform non maximum suppression to thin out the edges. • Non maximum suppression works by finding the pixel with maximum value in an edge. Suppose pixels p_1 and p_2 are located at positions (i_1, j_1) and (i_2, j_2), respectively.

- If the gradient magnitude of the pixel at position (i, j) is maximum, it is an edge point, and the gradient magnitude is used as its intensity; otherwise, the pixel is not an edge point, and its intensity is set to 0.

- The resulting image can be described as follows:

$$\varphi(i,j)=\begin{cases} G(i,j), & \text{if} \quad G(i,j)\geq G(i_1,j_1) \quad \text{and} \quad G(i,j)\geq G(i_2,j_2) \\ 0, & \text{otherwise} \end{cases}$$

- Since locations of pixels are discrete, gradient directions also need to be quantized.
- Take the 8-neighbouring domain, as shown in Figure 1, with the pixel at position (i, j) as an example. • Positions (i_1, j_1) and (i_2, j_2), of the neighbouring pixels p1 and p2 in the gradient direction can be computed as follows:

a. If $-\frac{1}{8}\pi < \theta(i,j) \le \frac{1}{8}\pi$, $\theta(i,j)$ is quantized as 0, and

$$(i_1, j_1) = (i, j-1), (i_2, j_2) = (i, j+1);$$

b. If $\frac{1}{8}\pi < \theta(i,j) \le \frac{3}{8}\pi$, $\theta(i,j)$ is quantized as $\frac{1}{4}\pi$, and

$$(i_1, j_1) = (i+1, j-1), (i_2, j_2) = (i-1, j+1);$$

c. If $-\frac{3}{8}\pi < \theta(i,j) \le -\frac{1}{8}\pi$, $\theta(i,j)$ is quantized as $-\frac{1}{4}\pi$, and

$$(i_1, j_1) = (i-1, j-1), (i_2, j_2) = (i+1, j+1);$$

d. If $\frac{3}{8}\pi < \theta(i,j) < \frac{1}{2}\pi$ or $-\frac{1}{2}\pi < \theta(i,j) < -\frac{3}{8}\pi$, $\theta(i,j)$ is quantized as $\frac{\pi}{2}$, and

$$(i_1, j_1) = (i-1, j), (i_2, j_2) = (i+1, j).$$

Non Maximum
Suppression

4. Thresholding with hysteresis

- Results obtained from non-maximal suppression is not perfect. Some edges may not actually be edges and there is some noise in the image. This leads to streaking problem.

- Streaking means the breaking up of an edge contour caused by the operator fluctuating above and below the threshold.
- Hysteresis using two $\tau_1 < \tau_2$ thresholds can eliminate streaking.

- If the $\varphi(i, j)$ value of the pixel at position (i, j) in the resulting image is larger than τ_2, the pixel is an edge pixel, and all such edge pixels constitute the edge output.

- Any pixel connected to this edge pixel and has its value larger than τ_1 is selected as an edge pixel.

Final Result from Canny Edge Detection Algorithm