CANNY EDGE DETECTOR

Edge detection

Objectives

- Low Error rate
- Edge points should be well localized
- Single edge point response

Process

1. Smoothing
2. Gradient
3. Non-maxima suppression
4. Hysteresis thresholding
5. Connectivity analysis

Gaussian Smoothing

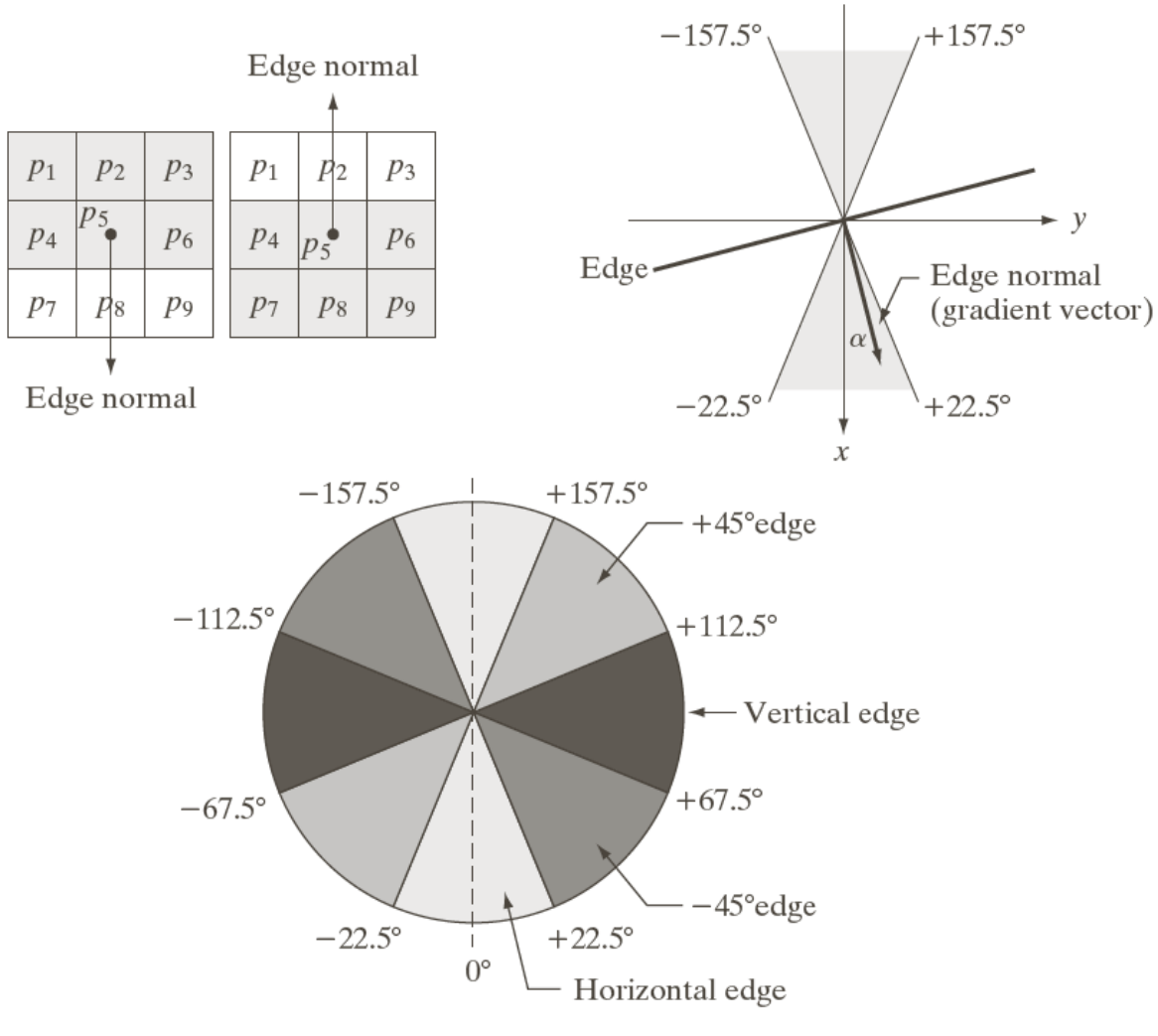
$$f_s(x, y) = G(x, y) \bigstar f(x, y)$$

Gradient

$$M(x, y) = \sqrt{g_x^2 + g_y^2}$$

$$\alpha(x, y) = \tan^{-1}\left[\frac{g_y}{g_x}\right]$$

Non-maxima Suppression



Non-maxima Suppression

1. Find the direction d_k that is closest to $\alpha(x, y)$.
2. If the value of $M(x, y)$ is less than at least one of its two neighbors along d_k, let $g_N(x, y) = 0$ (suppression); otherwise, let $g_N(x, y) = M(x, y)$

Hysteresis thresholding

$$g_{NH}(x, y) = g_N(x, y) \geq T_H$$

$$g_{NL}(x, y) = g_N(x, y) \geq T_L$$

$$g_{NL}(x, y) = g_{NL}(x, y) - g_{NH}(x, y)$$

Longer Edge formation

(a) Locate the next unvisited edge pixel, p, in $g_{NH}(x, y)$.
(b) Mark as valid edge pixels all the weak pixels in $g_{NL}(x, y)$ that are connected to p using, say, 8-connectivity.
(c) If all nonzero pixels in $g_{NH}(x, y)$ have been visited go to Step d. Else, return to Step a.
(d) Set to zero all pixels in $g_{NL}(x, y)$ that were not marked as valid edge pixels.

Final Edge image

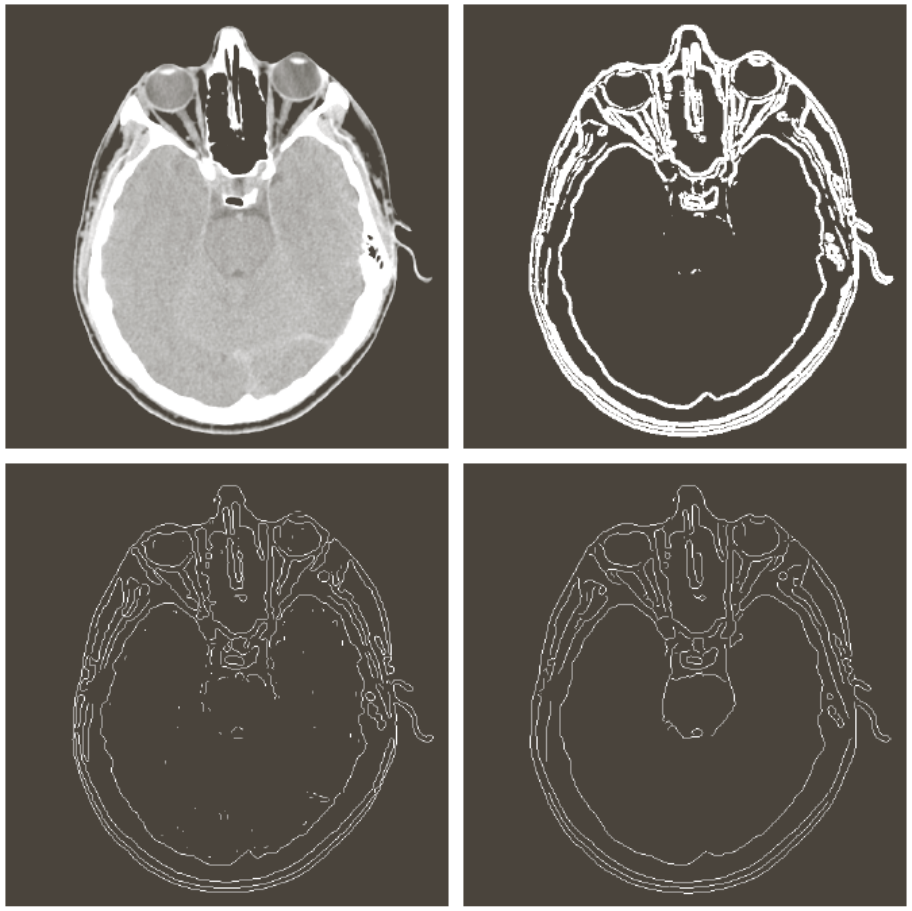
- Append all non-zero pixels of $g_{NL}(x,y)$ on $g_{NH}(x,y)$

Example

a b
c d

FIGURE 10.25
(a) Original image of size 834 × 1114 pixels, with intensity values scaled to the range [0, 1].
(b) Thresholded gradient of smoothed image.
(c) Image obtained using the Marr-Hildreth algorithm.
(d) Image obtained using the Canny algorithm. Note the significant improvement of the Canny image compared to the other two.

Example



a b
c d

FIGURE 10.26
(a) Original head CT image of size 512 × 512 pixels, with intensity values scaled to the range [0, 1]. (b) Thresholded gradient of smoothed image. (c) Image obtained using the Marr-Hildreth algorithm. (d) Image obtained using the Canny algorithm. (Original image courtesy of Dr. David R. Pickens, Vanderbilt University.)