(1) Canny Edge Detector :-

1) Gaussian Filter
2) Calculate Intensity Gradients
3) Non-maximum suppression
4) Thresholding with Hysterisis

process to Apply a Gaussian Filter :-

* Define matrix size (Usually odd numbers)

Gaussian Function :-

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

$x \rightarrow$ x cordinate value

$y \rightarrow$ y coordinate value

$\pi \rightarrow 3.13$

$\sigma \rightarrow$ standard deviation

↓

standard deviation in the Gaussian Function " controls the amount of blurring"

Small standard Deviation [blur less]

medium might be more useful.

A large standard Deviation [blur more]

x-coordinate = 10

y-coordinate = 20

$\sigma = 1$

$\pi = 3.13$

$$= \frac{1}{2 \times 3.13 \times (1)^2} \times e^{\left(\frac{-(10^2+20^2)}{2(1)^2} \right)}$$

$$= \frac{1}{6.26} \times e^{\left(\frac{-500}{2} \right)}$$

$$= \frac{1}{6.26} \times e^{-250}$$

$$= 2.66919e-109 \times \frac{1}{6.26}$$

$$= 1.00724e-109$$

Calculate Intensity Gradients :-

$$\begin{bmatrix} 150 & 150 & 150 & 255 & 255 \\ 150 & 150 & 255 & 255 & 1 \\ 150 & 255 & 255 & 1 & 1 \\ 255 & 255 & 1 & 1 & 1 \\ 255 & 1 & 1 & 1 & 1 \end{bmatrix}$$

5 x 5 patch

Gradient in the y-direction (G_y)

start

$$\begin{bmatrix} 150 & 150 & 150 & 255 & 255 \\ 150 & 150 & 255 & 255 & 1 \\ 150 & 255 & 255 & 1 & 1 \\ 255 & 255 & 1 & 1 & 1 \\ 255 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$ y-direction kernal

Convolute the selection in the original Image with the y kernel.

$$\begin{bmatrix} 150*-1 & 150*-2 & 150*-1 \\ 150*0 & 0 & 255*0 \\ 150*1 & 255*2 & 255*1 \end{bmatrix}$$

$$= \begin{bmatrix} -150 & -300 & -150 \\ 0 & 0 & 0 \\ 150 & 150 & 255 \end{bmatrix}$$

Adding up all the numbers in the matrix

→ G_y for the pixel in row 2, col 2 is 315

Calculation of Gradient in x-direction (G_x)

Taking the same pixel the result will be

$$\begin{bmatrix} 150 * -1 & 150 * 0 & 150 * 1 \\ 150 * -2 & 0 & 255 * 2 \\ 150 * -1 & 255 * 0 & 255 * 1 \end{bmatrix}$$

which becomes

$$\begin{bmatrix} -150 & 0 & 150 \\ -300 & 0 & 510 \\ -150 & 0 & 255 \end{bmatrix}$$

G_x for the pixel in row 2, col 2 is 315

Magnitude (G) = Square_root ($G_x^2 + G_y^2$)

$= (315^2 + 315^2)$

$\simeq 445$

" pixels with highest magnitude (G) are likely part of an EDGES "

Then calculate gradient direction Θ,

$$\Theta = \text{atan}\left(\frac{G_y}{G_x}\right)$$

$$= \text{atan}\left(315/315\right)$$

$$= \text{atan}(1)$$

$$= 0.78539 \text{ rad}$$

→ Perform Non-maximum suppression :-

Scans entire Image to get rid of pixels that are not part of an edge

a → b (edge) → c

If pixel b has more intensity than a and b

and

a and c are in gradient direction of b

than

b is considered as edge

→ Thresholding :-

Because Non-maximum suprension is not perfect for noisy situations.

Canny Edge Detector apply thresholding → to remove the weak and keep the strong