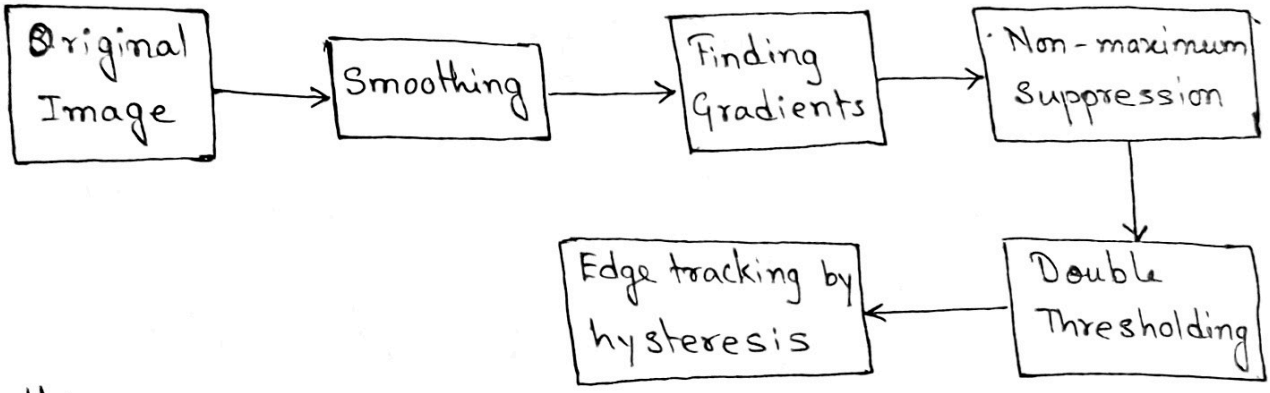
## Canny Edge Detection:

The canny edge detection algorithm is a multi-stage process that helps to identify the edges in an image by reducing noise and preserving important edge features. It is a gaussian based ~~edge~~ operator in edge detection. The canny operator is not susceptable to noise. It is widely used as an optimal edge detection technique.

## Steps for canny edge detection:




**Smoothing:** To prevent noise is mistaken for edges, noise must be reduced. Therefore the image is first smoothed by applying a Gaussian filter. The standard deviation for gaussiam filter is taken as $\sigma = 1.4$

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

**Finding Gradients:** When the image is smoothed, the derivatives $I_x$ and $I_y$ are calculated with respect to x and y axis. It can be implemented using the sobel-operator

$$K_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad K_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

after applying these Kernel we can use the gradient magnitudes and the angle to further process this step. The magnitude and angle can be calculated as,

$$|G| = \sqrt{I_x^2 + I_y^2}$$

$$\Theta(x,y) = \arctan\left(\frac{I_y}{I_x}\right)$$

Non-Maximum Suppression: This step aims at reducing the duplicate merging pixels along the edges making them uneven. Basically this is done to preserve all local maxima in the gradient image and deleting everything else. If the magnitude of the current pixel is greater than the magnitude of the neighbours nothing changes, otherwise the magnitude of the current pixel is set to zero.

Double Thresholding: The gradient magnitudes are compared with two specified threshold values, the first one is lower than the second. The gradients that are smaller than the lower threshold value are suppressed, the gradients higher than the high threshold value are marked as strong ones and the corresponding pixels are included in the final edge map. All the rest gradients are marked as weak ones and pixels corresponding to

-these gradients are considered in the next step.

Edge tracking using Hysteresis:

Strong edges are interpreted as "certain edges" and can immediately be included in the final edge image. Weak edges are included if and only if they are connected to strong edge. In other word there should be a chain of neighbor weak pixels connecting weak and strong gradient.