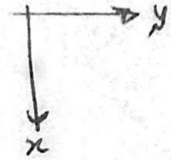
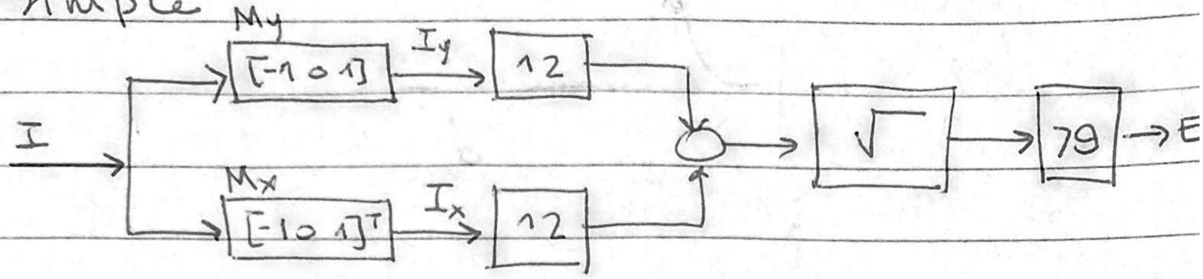


Edge Detection :

① Simple



Iy = imfilter (I, [-1 0 1]);
Ix = imfilter (I, [-1 0 1]');
E = sqrt(Ix .* Ix + Iy .* Iy) > theta;

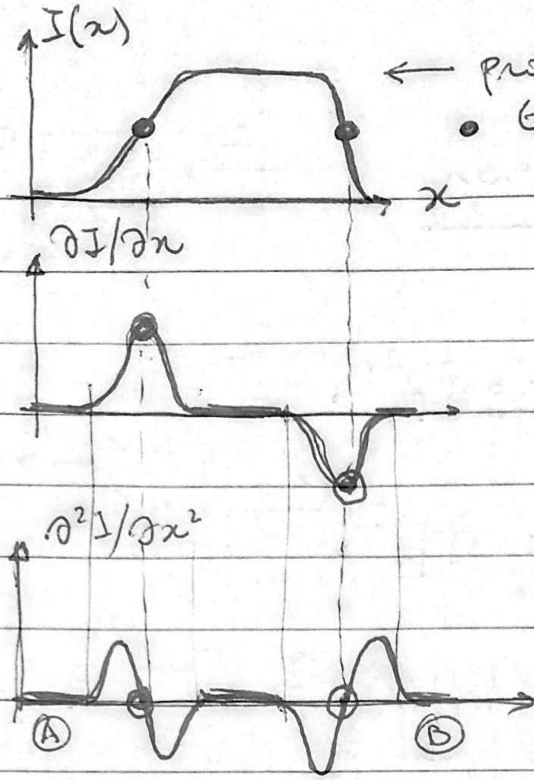
② Sobel

Similar to Simple, however, Mx and My are different:

$$M_y = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad M_x = M_y^T;$$

③ Laplacian-of-Gaussian (LoG)

Methods ① & ② are based on maximization of gradient. LoG, however, uses the second derivative. How?



← profile of a line

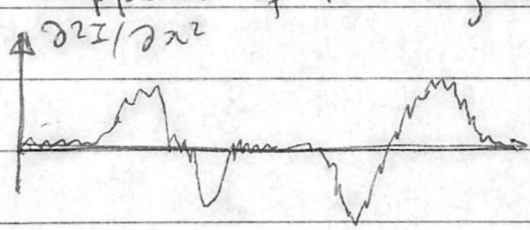
• Gradient is maximum.

⊙ zero-crossing

LoG detect the "zero-crossing" points because they correspond to the maximum gradient.

Zero-crossing ≠ zero values (Ⓐ and Ⓑ are not zero-crossing).

What happens if the signal is noisy?

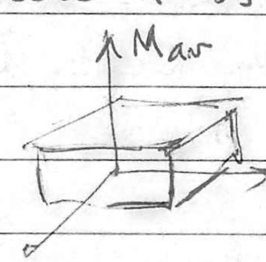


← Too many zero-crossing points

→ Solution : I should be filtered !

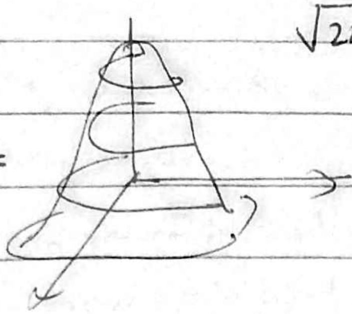
LoG uses a Gaussian Low Pass Filter.

Average : $M_{av} = \begin{bmatrix} 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \end{bmatrix} \frac{1}{n^2}$ →



$$\frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Gaussian

$M_{gauss} =$ 

LoG Block Diagram

$I \rightarrow$ [Low Pass F Gaussian] $\rightarrow$ [Second Derivative] $\rightarrow$ [Zero Crossing] $\rightarrow E$

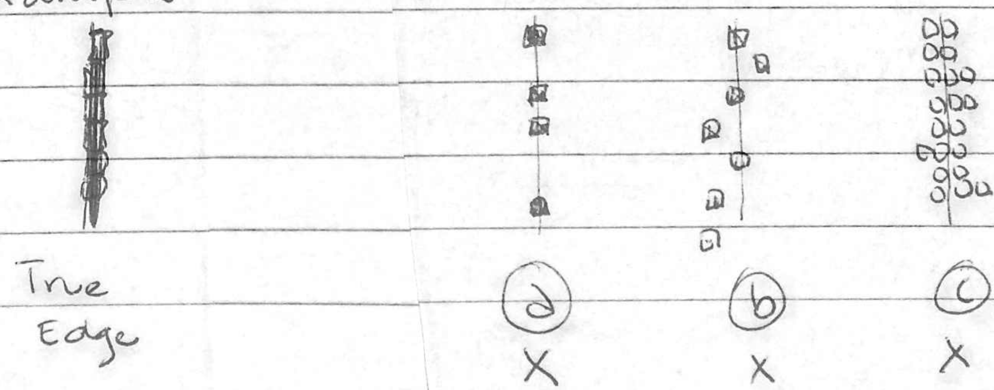
$$\frac{1}{\sqrt{2\pi\sigma}} \cdot \frac{x^2+y^2-2\sigma^2}{\sigma^4} e^{-\frac{x^2+y^2}{2\sigma^2}} \longrightarrow \text{Mexican Hat}$$

④ Canny

It search the "optimal" mask. It should fill the following criteria:

(a) Good Detection
(b) Good Localization
(c) Single Response

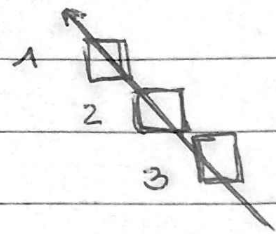
Example



The "optimal" mask is similar to a Gaussian Low Pass Filter (in x, in y direction

After filtering

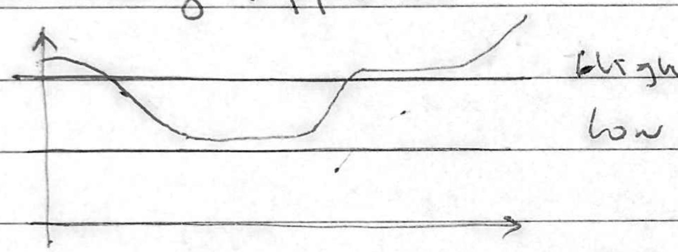
It uses non-maximum supression approach:

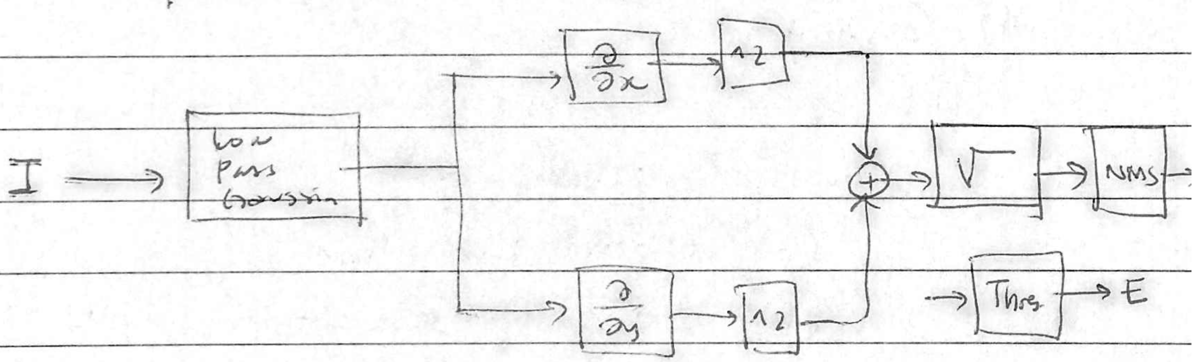


Pixels 1 and 3 are set to zero if $G_2 > G_1$ AND $G_2 > G_3$

direction of the gradient

After non-maximum supression it uses thresholding approach





(5) Morphological Gradient