Computer Vision HW1

마리암

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#1

In case of convolutions, they are associative and communitive so there is no difference of applying g or e first. But median filter is nonlinear that can not be implemented with linear kernels.

#2

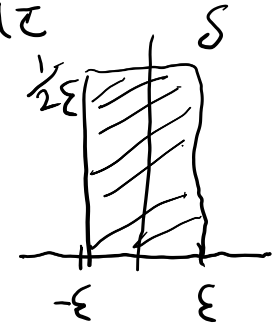
Dirac Delta function (unit impulse)! It is Zero everywhere except at zero, with an Integral of one over the entire line

Sifting property of the Dirac Delita:

At $\tau=0$ $\quad \int_{-\infty}^{\infty} f(\tau)\delta(\tau)\,d\tau = \int_{-\infty}^{\infty} f(0)\,\delta(\tau)\,d\tau$

$$= f(0)\int_{-\infty}^{\infty}\delta(\tau)\,d\tau = f(0)$$

At $\tau=T$ $\quad \int_{-\infty}^{\infty} f(\tau)\,\delta(\tau-T)\,d\tau = f(T)$



$$\text{so}\quad (f*\delta)(x) = \int_{-\infty}^{\infty} f(\tau)\,\delta(x-\tau)\,d\tau = f(x)$$

$$(\delta * h)(x) = \int_{-\infty}^{\infty} \delta(\tau)\,h(x-\tau)\,d\tau = h(x)$$

#3

2D Gaussian is separable, it can be written as product of two simple filters, the key idea to use two 1D gaussian filter is to use horizontal first then vertical so that can have several approximate filter

$$g(i,j) = \frac{1}{2\pi\sigma^2}\sum_{m=1}\sum_{n=1}\exp\left(-\frac{m^2+n^2}{2\sigma^2}\right)f(i-m,\,j-n)$$

$$\rightarrow g(i,j) = \frac{1}{2\pi\sigma^2}\underbrace{\sum_{m=1}\exp\left(-\frac{m^2}{2\sigma^2}\right)}_{X}\underbrace{\sum_{n=1}\exp\left(-\frac{n^2}{2\sigma^2}\right)}_{Y}f(i-m,j-n)$$

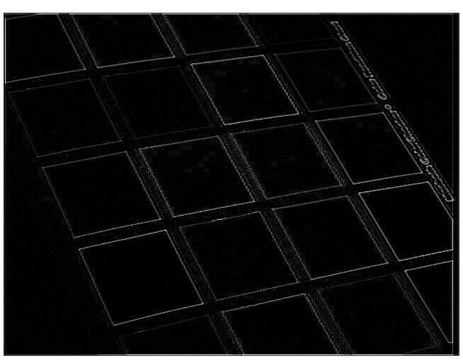
#4 if $g(x) = f(x) * g(x)$

By Fourier Transform	$G(w) = \int_{-\infty}^{\infty} g(x)\exp(-iwx)\,dx$
convolusion	$= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(\tau)h(x-\tau)\exp(-iwx)\,d\tau\,dx$
integration order change	$= \int_{-\infty}^{\infty} f(\tau)\int_{-\infty}^{\infty} h(x-\tau)\exp(-iwx)\,dx\,d\tau$
$v = x-\tau$	$= \int_{-\infty}^{\infty} f(\tau)\int_{-\infty}^{\infty} h(v)\exp(-iw(v+\tau))\,dv\,d\tau$
seprating	$= \underbrace{\int_{-\infty}^{\infty} f(\tau)\exp(-iw\tau)\,d\tau}\underbrace{\int_{-\infty}^{\infty} h(v)\exp(-iwv)\,dv}$
	$= F(w)H(w)$

convolusion in spatial domain $\Longleftrightarrow$ multiplication in frequency domain

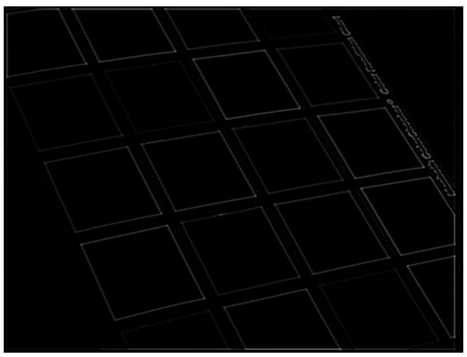
#5-2

By using Laplacian filter we get below image



This image contains noises so that we can reduce them by first apply smoothing then do Laplacian. By using Gaussian we do smooth the image then we can apply the Laplacian . this job is called LoG Laplacian of Gaussian .

$$\frac{\partial^2}{\partial x}(h * f) = \left(\frac{\partial^2}{\partial x} h\right) * f$$



After using Gaussian the noises reduced but still edges are not much visible much.

#5-5

In this part main key is to compare the edge strength of every pixel with strength of the positive and negative pixels gradient directions.

If strength of pixel is the largest compared to other pixels in the mask in same direction, then it will be preserved. In other hand it will be suppressed.

In other word, the pixel that is in direction of the y-direction means 90 degree, it will be compared to its above and below pixel.

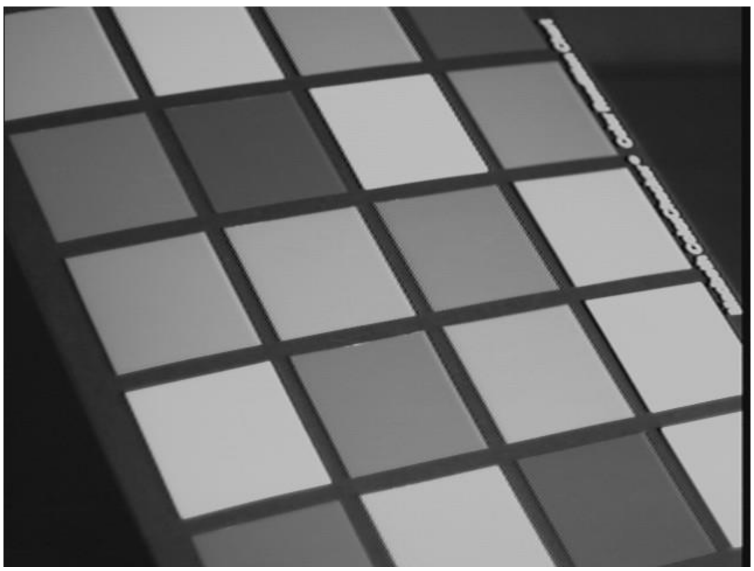
To make this comparation we consider if the angle is 0 , then the point is on the edge if its gradient magnitude is larger than the pixels in the right and left directions.

if the angle is 45, will be on the edge if its gradient magnitude is larger than the magnitudes than the pixels in the upright and down left directions.

if the angle is 90, will be on the edge if its gradient magnitude is larger than the magnitudes than the pixels in the up and down directions.

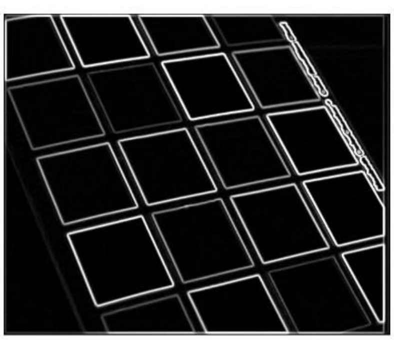
if the angle is 135°, will be considered to be on the edge if its gradient magnitude is larger than the magnitudes than the pixels in the up left and down right directions.

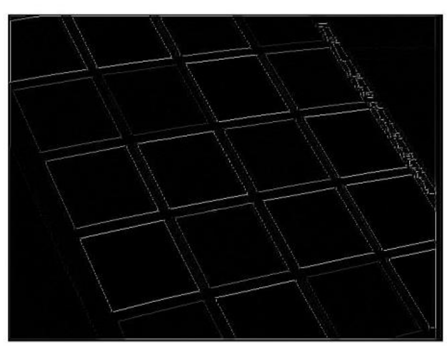
Here is the example on next page: here is original image



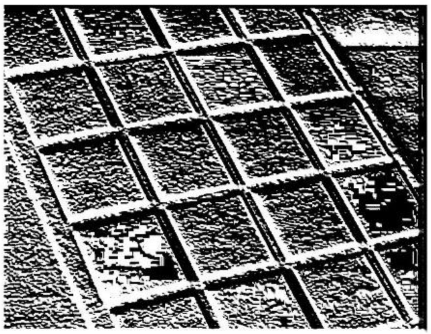
After applying sobel filter Non-maximum Suppression

IM In

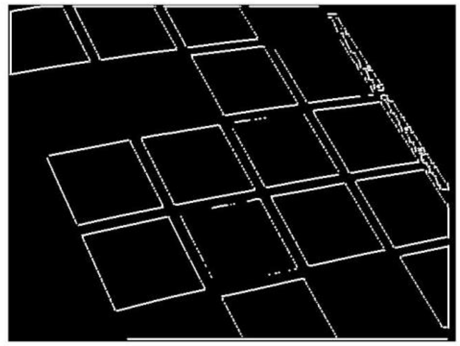




IO



I edge



I used tan2 instead of tan because after comparing the output I could see that the angles are more visible and there is less noise in it compare to using tan in sobel filter.

#5-6

As you can see in above Images after applying The Double Thresholding the edges become more visible but still some edges are disappeared, the parts that the picture edges were not bright.

I The Double Thresholding I did first multiply high thresholding and low thresholding values by the max value of Im (gradient magnitude) then if the pixel is larger than high thresholding it is edge and if it is still bigger than lower thresholding or its up, down, right, left neighborhood pixels then it is considered as week edge. Otherwise it will be suppressed.

For the example look at above image