CS 663 Home Work Assignment 2

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1 Question 4

Let us assume discrete 1D image $I(x)$ as an example and $\alpha = 0.5$. Where

$$I(x) = [10, 10, 8, 6, 4, 2, 0, 0, 0, 12, 0]$$

We know

$$\nabla^2 I(x) = \frac{\delta^2 I(x)}{\delta x^2} = I(x+1) + I(x-1) - 2 * I(x)$$

1.1 Case 1

Given that we need to $I(x) \leftarrow I(x) + \alpha\nabla^2 I(x)$

$S.No$	1	2	3	4	5	6	7	8	9	10	11
$I(x)$	10	10	8	6	4	2	0	0	0	12	0
$\nabla^2 I(x)$	x	-2	0	0	0	0	2	0	12	-24	x
$\alpha\nabla^2 I(x)$	x	-1	0	0	0	0	1	0	6	-12	x
$\alpha\nabla^2 I(x) + I(x)$		9	8	6	4	2	1	0	6	0	

Clearly we can observe that the pixels with low intensity are increasing (for example consider pixels numbers $7, 9$ whose intensities were increased from $0, 0$ to $1, 6$) and pixels with high intensity are decreasing (for example consider the peak pixel numbers 2, 10 whose intensity value were decreased from 10, 12 to 9, 0 respectively).

We can write consider the above operation ∇^2 filter as,

$$\nabla^2 = (1, -2, 1)$$

Therefore,

$$\implies \alpha\nabla^2 I + I = (0, 1, 0) + \alpha(1, -2, 1)$$

$$\implies (0, 1, 0) + \alpha(1, 1, 1) + \alpha(0, -3, 0)$$

Observe that we are adding $(1, 1, 1)$ every-time this is basically adding intensity mean of the adjacent pixels to the current pixel. Hence this gives the intuition of mean filter (discussed in class) being added which is used for blurring in general and we also observed that local maximum peak intensity (Observe pixel number 10) value decreases and for local minimum value increases results in blurring of the image. As the number of iterations increases, the intensity values are getting closer i.e, intensity values of all pixels tend towards the average intensity.

1.2 Case 2

Given that we need to $I(x) \leftarrow I(x) - \alpha\nabla^2 I(x)$

$S.No$	1	2	3	4	5	6	7	8	9	10	11
$I(x)$	10	10	8	6	4	2	0	0	0	12	0
$\nabla^2 I(x)$	x	-2	0	0	0	0	2	0	12	-24	x
$\alpha\nabla^2 I(x)$	x	-1	0	0	0	0	1	0	6	-12	x
$I(x) - \alpha\nabla^2 I(x)$		11	8	6	4	2	-1	0	-6	24	

Clearly we can observe that the pixels with low intensity are decreasing (for example consider pixels numbers $7, 9$ whose intensities were decreased from $0, 0$ to $-1, -6$) and pixels with high intensity are increasing (for example consider the peak pixel numbers 2, 10 whose intensity value were increased from 10, 12 to 11, 24 respectively).

We can write consider the above operation ∇^2 filter as,

$$\nabla^2 = (1, -2, 1)$$

Therefore,

$$\implies I - \alpha\nabla^2 I = (0, 1, 0) - \alpha(1, -2, 1)$$
$$\implies (0, 1, 0) - \alpha(1, 1, 1) + \alpha(0, 3, 0)$$

Observe that we are subtracting $(1, 1, 1)$ every-time this is basically subtracting intensity mean of the adjacent pixels from the current pixel. Hence this gives the intuition of mean filter (discussed in class) being subtracted. Since addition of mean filter leads to blurring, subtracting leads to sharpening of the image and we also observed that *local maximum peak intensity* (Observe pixel number 10) value *increases further* and for *local minimum value decreases further* resulting in increasing the difference between the intensities of adjacent pixels. As the number of iterations increases this intensity difference keeps on increasing (**increasing contrast**) making some intensities $+\infty$ and others $-\infty$ hence image will become **highly distorted**
We can also extend this analogously to 2D images also.