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CS555/455

Assignment 2

1. (10%) Given following four masks, order them in that generating smooth images from light smoothness to heavy smoothness, Explain why.

M1:

1	1	1
1	1	1
1	1	1

M2:

1	2	1
2	4	2
1	2	1

M3:

0	1	0
1	4	1
0	1	0

M4:

0	0	0
0	1	0
0	0	0

The image will retain more of its original quality if the central element in the kernel has a higher relative weight to the others.

M1 $\frac{1}{9}$ = 11% ← Heaviest smoothness. Only 11% of original pixel intensity retained.

M2 $\frac{4}{16}$ = 25%

M3 $\frac{4}{8}$ = 50%

M4 $\frac{1}{1}$ = 100% ← Lightest smoothness, 100% of original pixel intensity retained.

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2. (8%) The filter for image enhancement can be designed by first-order derivatives and second-order derivatives. Compare the first-order derivatives and the second-order derivatives, which one is better for image enhancement. Explain why.

1st order derivative filters (e.g. Sobel) retain a lot of noise and you usually need to further process them (hysteresis thresholding) to get a good edge image.

2nd order derivative filters (Laplacian of Gaussian) are less noisy and can be used in zero-crossing.

Neither is definitively better; different filters for different occasions.

3. (8%) An edge image (E) is generated by filtering a gray scale image (I) by a Laplacian mask (M). The sharpening image can be obtained by simply adding the original image (I) and the edge image (E). Show a single mask (S) based on the mask M such that the image sharpening can be implemented with one pass of the single mask.

$$M = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$E = (I)M$

$H = I + E$

$H = I + (I)M$

$H = (I)S$?

$-1(M) = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$

$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix} = S$

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4. (8%) To extract edge information of an image, people can either

(**A**) Blur the image first, then apply edge detector

or

(**B**) Apply edge detector first, then do the image blurring.

Which way is better? Explain why.

A is better. By first blurring the image, we diminish the effect of noise that will look like weak edges. This way, we only extract the more important edges when we apply the edge detector.

5. (12%) Apply the median filter to remove the noises in the following image I:

4	4	4	4	4	4	4	4
4	4	4	48	4	4	4	4
4	4	64	64	64	64	4	4
4	17	64	64	96	64	4	4
4	4	64	85	64	64	8	4
4	4	64	64	64	64	4	4
4	56	4	4	23	4	4	4
4	4	4	4	4	4	4	4

(note: assume that all the pixels outside the image have value: 4)

(a) Use 3*3 square-shape median filter to filter image I, obtain image M1;
(b) Use 5*5 cross-shape median filter to filter image I, obtain image M2;
(c) Compare M1 and M2, indicate which filter is better, and explain why.

a) Square Filter

4	4	4	4	4	4	4	4
4	4	48	4	4	4	4	4
4	17	64	64	64	4	4	4
4	64	64	64	64	8	4	4
4	64	64	64	64	8	4	4
4	56	64	64	64	4	4	4
4	4	4	23	4	4	4	4
4	4	4	4	4	4	4	4

b) Cross Filter

4	4	4	4	4	4	4	4
4	4	4	4	4	4	4	4
4	4	64	64	64	64	64	4
4	4	64	64	64	64	64	4
4	4	64	64	64	64	64	4
4	4	64	64	64	64	64	4
4	4	4	4	4	4	4	4
4	4	4	4	4	4	4	4

c) The square median filter is better. It provides a more localised view of the image and also maintains more of the original image. Additionally, the cross filter fails to account for the diagonals.