CS 355 Homework #6:
Simple Image Processing Operations

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1. Spatially filter (convolve) the image on the left with the 3 x 3 mask (kernel) shown. State the assumptions you make for the pixels outside the source image.

   ANSWER: *Here is the answer assuming 0 padding. If you made other assumptions for the border pixels, the center* 3×3 *area should still be the same.*

0	0	0	0	0
0	0	1	0	0
0	1	2	1	0
0	0	3	0	0
0	0	0	0	0

Input Image

*

1	2	1
2	4	2
1	2	1

Mask

=

0	1	2	1	0
1	6	10	6	1
2	12	20	12	2
1	10	18	10	1
0	3	6	3	0

Output Image

2. What is the result of mean filtering (averaging pixels with their 8-connected neighbors) for the following image?

   ANSWER: *Here is the answer again assuming 0 padding. If you made other assumptions for the border pixels, the center* 3×3 *area should still be the same.*

10	11	9	25	22
8	10	9	26	28
9	99	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

4	6	10	13	11
16	19	25	20	17
16	20	25	20	16
17	20	24	19	16
5	7	10	13	10

Output Image

3. What is the result of median filtering (using 8-connected neighbors) for the following image?

   ANSWER: *Here is the answer again assuming 0 padding. If you made other assumptions for the border pixels, the center* 3×3 *area should still be the same.*

10	11	9	25	22
8	10	9	26	28
9	99	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

0	9	9	9	0
9	9	11	24	24
9	10	12	23	23
10	11	12	22	22
0	10	11	12	0

Output Image

4. What is the result of unsharp masking using an $A = 1$ (a 5 in the center) mask?

   ANSWER: *Here is the answer again assuming 0 padding. If you made other assumptions for the border pixels, the center* 3×3 *area should still be the same. This is* without *clipping negative values. If you clip these values (as you should for unsigned pixel types), the two negative values should be 0.*

10	11	9	25	22
8	10	9	26	28
9	8	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

31	26	0	68	57
11	14	-9	44	67
18	1	-8	37	51
25	13	8	35	37
28	25	0	53	81

Output Image

5. This question walks through the computational steps for gradient-magnitude edge detection for the following image: (For this question, don't worry about the border pixels.)

10	11	9	25	22
8	10	9	26	28
9	8	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

   ANSWER: *For the following answers, I've shown the values to one decimal place. If you've rounded to integers, that's OK. The* y *derivatives might be negated depending on which way you have as the positive* y *direction, but that doesn't change the gradient magnitude once you square these values.*

   (a) What is the result of applying the x-derivative Sobel filter? (Remember to divide by 8.)

X	X	X	X	X
X	0.1	7.8	8.4	X
X	0.3	7.5	7.6	X
X	0.1	6.4	6.5	X
X	X	X	X	X

   (b) What is the result of applying the y-derivative Sobel filter? (Remember to divide by 8.)

X	X	X	X	X
X	-0.9	-0.5	0.1	X
X	1.0	0.5	-1.1	X
X	0.9	0.1	-0.5	X
X	X	X	X	X

(c) What is the gradient magnitude at each pixel?

X	X	X	X	X
X	0.9	7.8	8.4	X
X	1.0	7.5	7.7	X
X	0.9	6.4	6.5	X
X	X	X	X	X