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APPM4058A & COMS7238A: Digital Image Processing
Exercise 3

2019-2-20

1 Problems

1. Consider the image in Table 1. Apply each of the given filters (a), (b), and comment on the results.

2	3	8	9	8
1	2	1	7	9
9	3	2	5	8
7	9	1	1	7
9	8	9	1	2

(a) $\frac{1}{8}\times$

0	1	0
1	4	1
0	1	0

(b)

-1	-1	-1
-1	8	-1
-1	-1	-1

Table 1: The image and filters for Question 1

2. What would be the purpose of the filter in Table 2 be? How would it differ from the filters in Question 1?

0	-1	0
-1	5	-1
0	-1	0

Table 2: The filter for Question 2

3. In a given application, an averaging mask is applied to input images to reduce noise, and then a Laplacian mask is applied to enhance the small details. Would the result be the same if the order of these operations were reversed?
4. Some filters can be decomposed into two subfilters. For example

$$\begin{pmatrix}1\\2\\1\end{pmatrix} * \begin{pmatrix}1 & 2 & 1\end{pmatrix} = \begin{pmatrix}1 & 2 & 1\\ 2 & 4 & 2\\ 1 & 2 & 1\end{pmatrix} \tag{1}$$

   How could this be helpful in computing the results of filters on images?
5. Given the following transformation function,

$$g(x,y) = \begin{cases} Af(x,y) - \Delta^2 f(x,y) & \text{If the center coefficient of Laplacian mask is negative} \\ Af(x,y) + \Delta^2 f(x,y) & \text{If the center coefficient of Laplacian mask is positive} \end{cases} \tag{2}$$

   - Explain what does the filter do when $A = 1$. What is the effect of this transformation? Give an example of such mask with the size 3×3. What if $A > 1$?
6. Discuss the limiting effect of repeatedly applying a 3×3 smoothing filter to a digital image.

7. In a character recognition application, text pages are reduced to binary form using a thresholding transformation function. This is followed by a procedure that thins the characters until they become strings of 1's on a background of 0's. Due to noise, the binarization and thinning process result in broken strings of characters with gaps ranging from 1 to 3 pixels. One way to repair the page is to run an averaging mask over the binary image to blur it, and thus create bridges of nonzero pixels between gaps. Give the size of the smallest averaging mask capable of performing this task.

2 Lab exercise

1. Write a program that can create a mask of size $N \times N$ Gaussian filter.

2. Write a spatial filtering function that takes in an image, I, an $N \times N$ filter as arguments, and obtain an output image by performing spatial filtering operation on image I. Consider different ways, such as padding zeros or replication, of handling the border pixels of the input image.

3. Using the spatial filtering function in Item 2 to perform a Laplacian filtering on image 'blurry_moon'. Save your output image as 'blurry_moon_laplacian.png'.

4. Apply spatial filtering on image 'ckt_board' using an box filter and a median filter, respectively. Save the output images as 'ckt_board_box.png' and 'ckt_board_median.png', respectively.

5. The image 'skeleton' shows a whole body bone scan, which is used to detect disease such as bone infection and tumors. Using the image enhancement techniques we discussed so far in the class to enhance this image. The objective is to sharpen the image and bring out more of the skeletal detail. For this purpose, consider approaches to highlight fine detail, enhance prominent edges, and increase the dynamic range in the image.