南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Course Name： EE326 Digital Image Processing **Dept.：** EEE

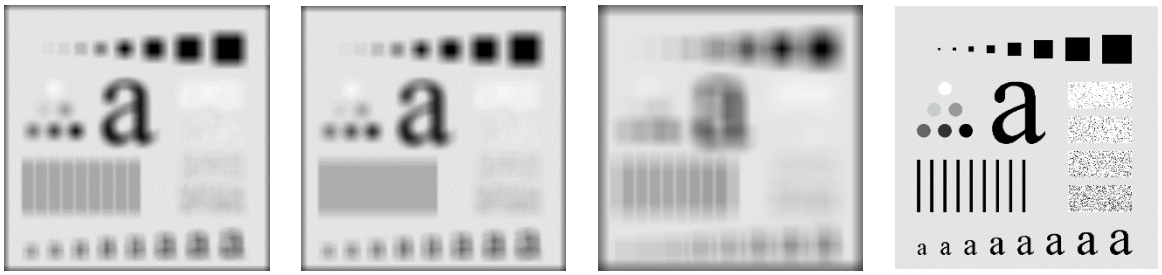
Exam Duration： 2 hours **Exam Paper Setter：** Yu Yajun

Question No.	1	2	3	4	5	6	7	8	9	10
Score	25	25	25	25	-	-	-	-	-	-

This exam paper contains 4 questions and the score is 100 in total. (Please hand in your exam paper, answer sheet, and your scrap paper to the proctor when the exam ends.)

1. Answer the following 3 questions.

(i) The three images (a) – (c) shown in Figure 1 were obtained by blurring the image (d) using square average masks of sizes n = 23, 25, and 45, respectively. It is known that the vertical bars on the left lower part of image (d) are 5 pixels wide, 100 pixels high, and their separation is 20 pixels. It is observed that the vertical bars of (a) and (c) blurred, but a clear separation exists between them. However, the bars have merged in image (b), in spite of the fact that the mask that produced this image is significantly smaller than the mask that produced image (c). Explain the reason for this.



(a) (b) (c) (d)

Figure 1

(ii) The discrete Fourier transform (DFT) of an M by N image $f(x,y)$ is given by

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

Suppose that you pad the image with zeros to size P by Q. What is the ratio of the DC component of the DFT of the original image and of the padded image?

(iii) The image shown in Figure 2 is a blurred, 2-D projection of a volumetric rendition of a heart. It is known that each of the cross hairs (交叉丝) on the right bottom part of the image was 4 pixels wide, 20 pixels long, and had an intensity value of 255 before blurring. Provide a step-by-step procedure indicating how you would use the information given to obtain the blurring (degradation) function $H(u,v)$.

(25 marks)

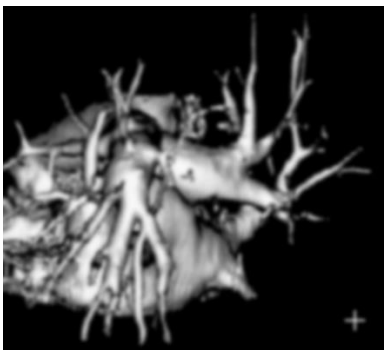


Figure 2

2. Consider a 3-level grey image $f(x,y)$ of size 256 x 256 shown in Figure 3, where $0 \leq x,y \leq 255$. The intensity of this image is constant and equal to $r1$ for the majority of the pixel locations. Insidethe image there is a pattern of two small square areas. The smallest area is of intensity $r2$ and occupies the pixels at locations $144 \leq x,y \leq 175$. This is placed within a slightly larger square area which occupies the pixels at locations $128 \leq x,y \leq 191$. The intensities of this area are $r3$ apart from the locations for the smallest square.
The intensities $r1, r2$, and $r3$ lie within 0 to 255, $r3 < r2 < r1$, and $r2 = r3 + 1$.

(i) Plot the histogram of the image $f(x,y)$ with labels to indicate values on the plot.

(ii) Apply a global histogram equalization to the image $f(x,y)$, and plot the histogram of the resultant image with labels. Show you steps in the histogram equalization computation.

(iii) Apply a local histogram equalization to the image $f(x,y)$ by dividing the image in non-overlapping patches of 64 x 64. Plot the histogram of the resultant image with labels.

(iv) State which histogram equalization method is better for the image and why?

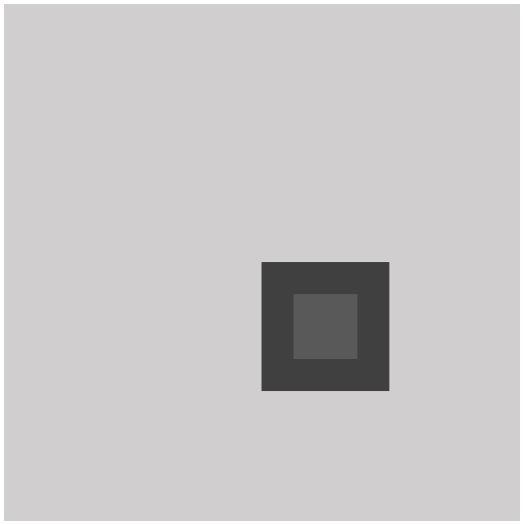


Figure 3

(25 marks)

3. The gradient of a function $f(x)$ is defined as

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Computationally, the first derivative is implemented by calculating the difference between adjacent pixels.

(i) Is the following a linear operator?

$$|\nabla f| = \left[\left(\frac{\partial f}{\partial x} \right)^2 + \left(\frac{\partial f}{\partial y} \right)^2 \right]^{\frac{1}{2}}$$

(ii) State how would you implement the above operator using differences between pixels.

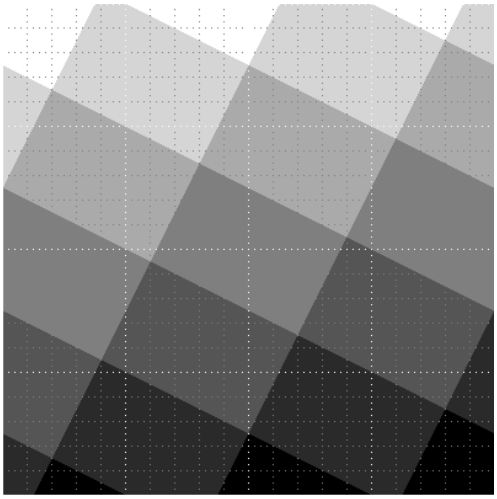
(iii) A Sobel operator uses two masks, H_x and H_y to process an image. Explain why are two masks needed and what do they measure?

(25 marks)

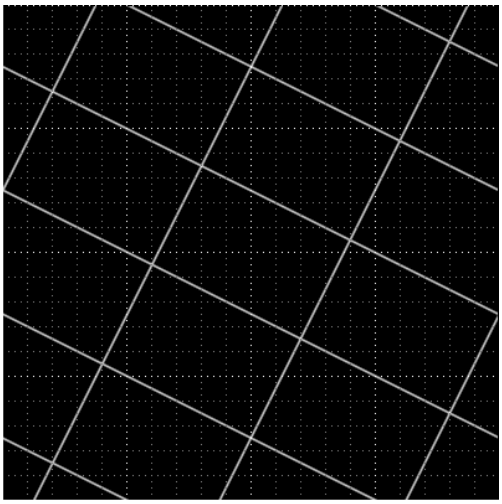
4. An image of a scene with a pattern of rectangles is shown in Figure 4(a). The image array is 400 x 400 pixels. A set of gridlines has been placed on top of the image. Assume that (0, 0) is at the left-top corner. Figure 4(b) is an image that was produced by using an edge detector on image (a), with the same set of gridlines imposed. Figure 4(c) shows a contour plot of a Hough transform that was produced from image (b).

(i) Derive and / or explain the relationship between the lines in (a) and (b) and the major features of (c).

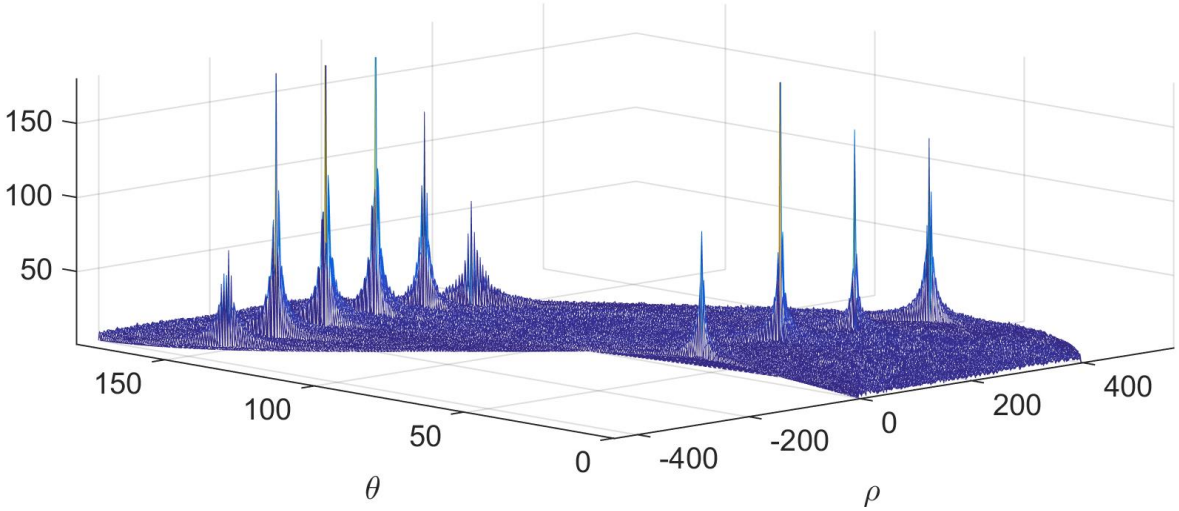
(ii) Match corresponding lines and features. Provide numerical values to justify your result.
To facilitate your explanation, the lines in image (b) are denoted as v_1, v_2, v_3, v_4 for the 4 lines closer to vertical, from left to right, and $h_1, h_2, \ldots, h_6$ for the 6 lines closer to horizontal, from top to down, whereas the spikes in figure (c) are denoted as $s_1, s_2, \ldots, s_{10}$, from left to right.



(a)



(b)



(c)

Figure 4

(25 Marks)

-- End of Exam Paper --