**Problem 1** The following small image has gray values in the range 0-19. Compute the gray level histogram and the mapping that will equalize this histogram. Produce the 8x8 grid containing the gray values for the new histogram-equalized image.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | 9 | 13 | 13 | 16 | 19 | 19 | 17 |
| 12 | 10 | 14 | 15 | 18 | 18 | 16 | 14 |
| 11 | 8 | 10 | 12 | 14 | 13 | 14 | 15 |
| 8 | 6 | 3 | 7 | 9 | 11 | 12 | 12 |
| 12 | 6 | 5 | 13 | 14 | 14 | 16 | 15 |
| 11 | 10 | 8 | 5 | 8 | 11 | 14 | 14 |
| 9 | 8 | 3 | 4 | 7 | 12 | 18 | 19 |
| 10 | 7 | 4 | 2 | 10 | 12 | 13 | 17 |

**Problem 2** We have a 512×512 image, as shown in Fig. 1.1, the pixel value of ($x$,$y$) is represented by $I(x,y)$. (a) rotate the image 30 degree clockwise about the point ($x$,$y$) = (0, 0), as shown in Fig 1.2, what is the intensity value of (238,247) after rotation by using bilinear interpolation? (b) rotate the image 30 degree clockwise about the point ($x$,$y$) = (255, 255), as shown in Fig 1.3, what is the intensity value of (238,247) after rotation by using bilinear interpolation? Represent the answer by $I$. ($\sqrt{3}$ = 1.732)

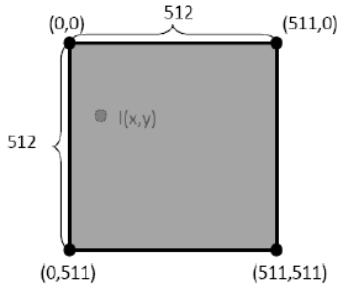


Fig.1.1

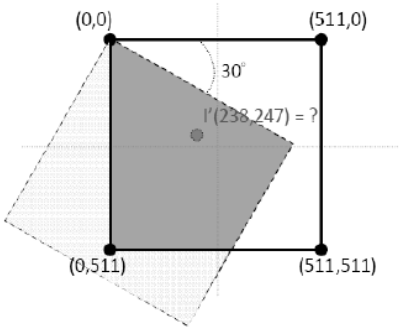


Fig.1.2

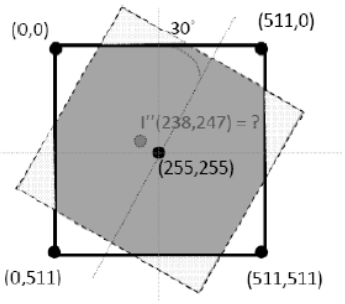


Fig.1.3

**Problem 3** Suppose that you apply a two-dimensional Laplacian spatial filter, i.e.

$$g(x,y) = [f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1)] - 4f(x,y)$$

(a) Find the equivalent filter $H(u, v)$ in the frequency domain.

(b) Show that your result is a highpass filter.

**Problem 4** The following image I(x,y) of size NxN is corrupted by salt-and-pepper noise(with probabilities $P_a = P_b = 0.25$). Let f(x,y) denote the filtered result of I(x,y).

Note: You have to define every notation you use in your answer.

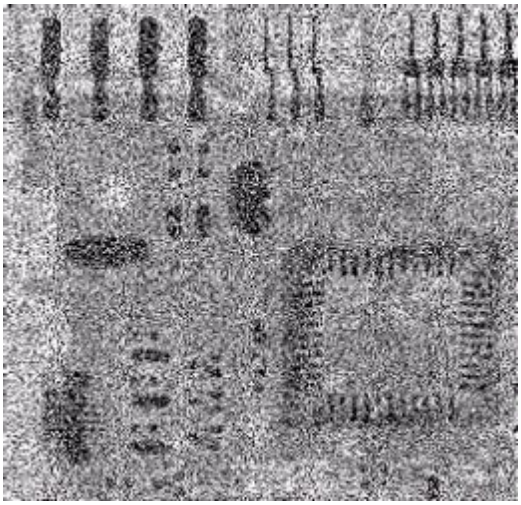

Figure 4.1

(a) Write down the algorithm of processing I(x,y) with an adaptive median filter.
Explain how it works. You are asked to give all the details and situations you can think of.

(b) One of the following two images is processed by a 7×7 median filter, and the other by an adaptive median filter. Can you tell which is which? Give your reasons for your choice as detailed as possible.

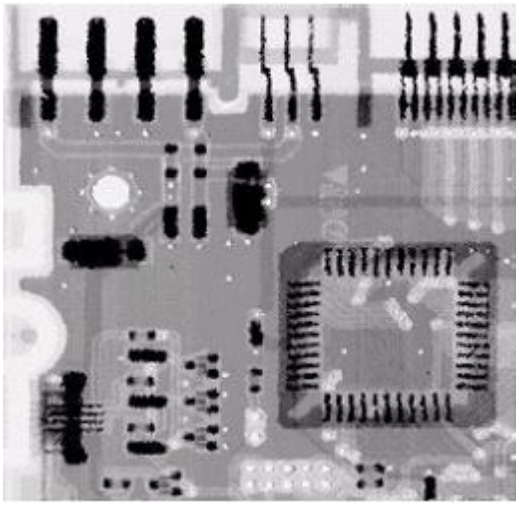

Figure 4.2

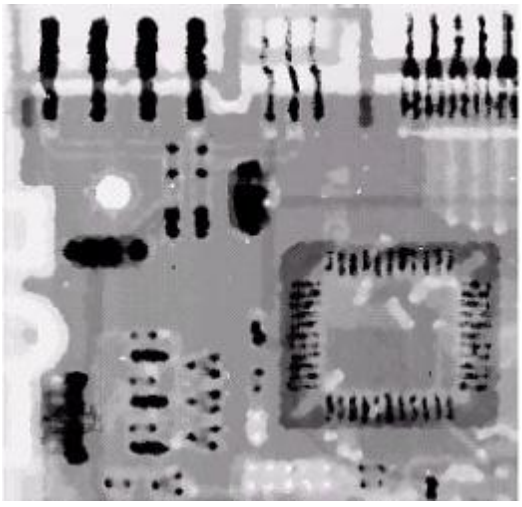

Figure 4.3

**Problem 5** What is full-scale histogram stretch? What is histogram equalization? What is their difference when used for image enhancement?