数字图像处理及应用 第4次作业

组号： XX（两位数字） 小组成员： （列出所有小组成员，成员姓名间用1个空格间隔）

Part I Exercises

Ex.1 The image shown in FIGURE 1 consists of two infinitesimally thin white lines on a black background, intersecting at some point in the image. The image is input into a linear, position invariant system with the impulse response given as Eq.1.

$$h(x,y) = e^{-[(x-\alpha)^2+(y-\beta)^2]} \tag{1}$$

Assuming continuous variables and negligible noise, find an expression for the output image $g(x,y)$.

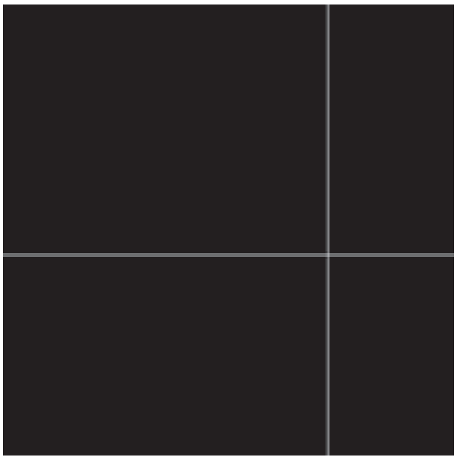

FIGURE 1

Answer:

Ex.2 During acquisition, an image undergoes uniform linear motion in the vertical direction for a time T_1. The direction of motion then switches to the horizontal direction for a time interval T_2. Assuming that the time it takes the image to change directions is negligible, and that shutter opening and closing times are negligible also, give an expression for the blurring function, $H(u,v)$.

Answer:

Ex.3

(**a**) The image in (b) and (c) were obtained by inverse and Wiener-filtering the image in (a), which is a motion blurred image that, in addition, is corrupted by additive Gaussian noise. The blurring itself is corrected in (b) and (c). However, the restored image (b) has a strong streak pattern that is not apparent in (a) [for example, compare the area of constant white in the top right of (b) with the corresponding are in (a).] On the other hand, the streak pattern does not appear in (c). Explain how this pattern originated and why Wiener filter can avoid it.

(**a**)	(**b**)	(**c**)

FIGURE 2 Inverse and Wiener filtering

Answer:

Ex.4 A certain X-ray imaging geometry produces a blurring degradation that can be modeled as the convolution of the sensed image with the spatial, circularly symmetric function

$$h(x,y) = \frac{x^2+y^2-2\sigma^2}{\sigma^4} e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{2}$$

Assuming continuous variables, show that the degradation in the frequency domain is given by the expression

$$H(u,v) = -8\pi^3\sigma^2(u^2+v^2)e^{-2\pi^2\sigma^2(u^2+v^2)} \tag{3}$$

Answer:

Ex.5 The image shown is a blurred, 2-D projection of a volumetric rendition of a heart. It is known that each of the cross hairs 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 just given to obtain the blurring function $H(u, v)$.

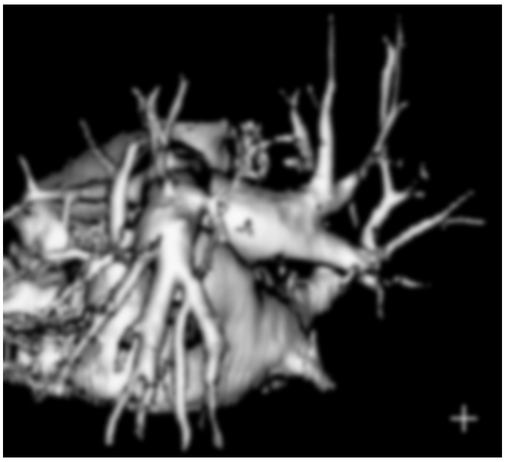

FIGURE 3 Volumetric rendition of a heart

Answer:

Ex.6 Explain the reason for the formation of image (d) in FIGURE 4 (refer to Example 4.6 in page 252)， which is acquired by an imaging system with maximum sampling rate of 96×96. The original image of (d) is a checkerboard like image, which each of its square is of 0.4798×0.4798 pixels.

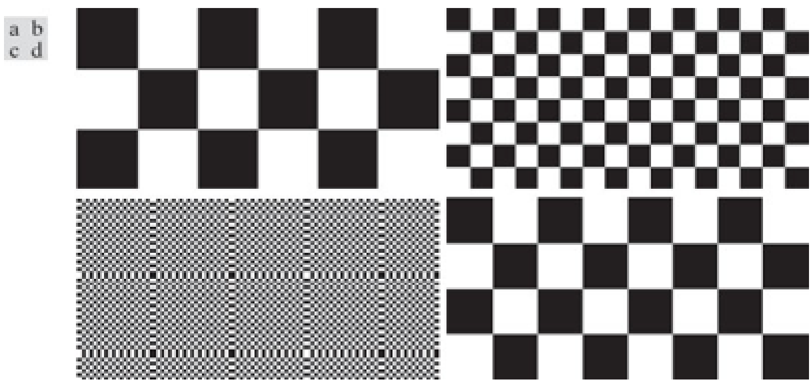

FIGURE 4 Aliasing in image

Part II Programming

1. The arithmetic mean filter is defined as

$$\hat{f}(x,y) = \frac{1}{mn} \sum_{(s,t)\in S_{xy}} g(s,t). \tag{1}$$

The white bars in the test pattern shown are 7 pixels wide and 210 pixels high. The separation between bars is 17 pixels. What would this image look like after application of

(**a**) A 3×3 arithmetic mean filter?
(**b**) A 7×7 arithmetic mean filter?
(**c**) A 9×9 arithmetic mean filter?

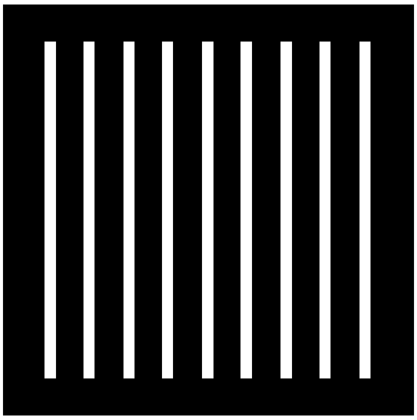

FIGURE 5 Test pattern

(*followed by* ***Matlab live Scripts*** *or* ***Jupyter Scripts*** *and running results*)

2. Repeat **1** using a geometric mean filter which is defined as

$$\hat{f}(x,y) = \left[\prod_{(s,t)\in S_{xy}} g(s,t)\right]^{\frac{1}{mn}}. \tag{2}$$

(*followed by* ***Matlab live Scripts*** *or* ***Jupyter Scripts*** *and running results*)

3. Repeat **1** using a harmonic mean filter which is defined as

$$\hat{f}(x,y) = \frac{mn}{\sum_{(s,t)\in S_{xy}} \frac{1}{g(s,t)}}. \tag{3}$$

(*followed by* ***Matlab live Scripts*** *or* ***Jupyter Scripts*** *and running results*)

4. Sketch what the image in FIGURE 6 would look like if it were blurred using the transfer function

$$H(u,v) = \frac{T}{\pi(ua+vb)} sin[\pi(ua+vb)]e^{-j\pi(ua+vb)} \tag{4}$$

(**a**) With $a = b = 0.1$, and $T = 1$.

(**b**) In addition, add Gaussian noise into the resulting image of (a), with zero mean and variance of 650.

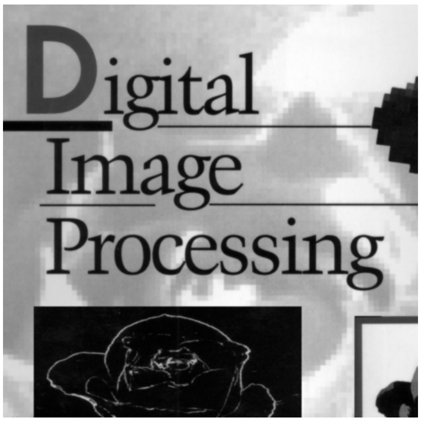

FIGURE 6

Try to restore the degraded image after procedure (b) using inverse filter, Wiener filter, and constrained least squares filter.

(*followed by* ***Matlab live Scripts*** *or* ***Jupyter Scripts*** *and running results*)