Digital Image Processing
Fall 2015
Midterm Exam
11/23/2015

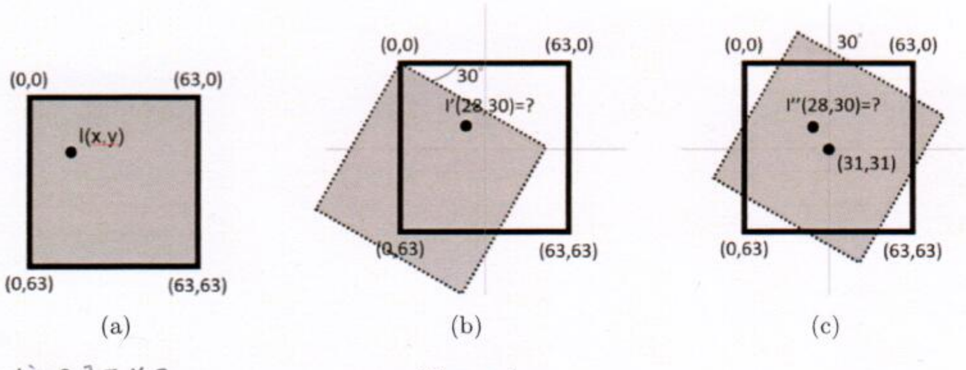
Name : ____________________
Student ID : ____________________

Note:

1. This exam contains 4 pages and 7 problems. Check to see if any pages are missing. Enter your name and student ID on the top of this page.
2. You may *not* use your books, notes, or any calculator on this exam.
3. You are required to show your work on each problem on this exam.
4. You have to turn in answer sheet and question sheet.

Good Luck!

1. (20 points) We have a 64×64 image, as shown in Figure 1(a), where the pixel value of (x, y) is represented by $I(x, y)$.
   (a) (10 points) Rotate the image 30 degree clockwise about the point $(x, y) = (0, 0)$, as shown in Figure 1(b). What is the intensity value of $(28, 30)$ after rotation using bilinear interpolation? Express your answer by I.
   (b) (10 points) Rotate the image 30 degree clockwise about the point $(x, y) = (31, 31)$, as shown in Figure 1(c). What is the intensity value of $(28, 30)$ after rotation using bilinear interpolation? Express your answer by I. ($\sqrt{3} = 1.732$)



(a) (b) (c)

Figure 1

(b)
旋轉矩陣

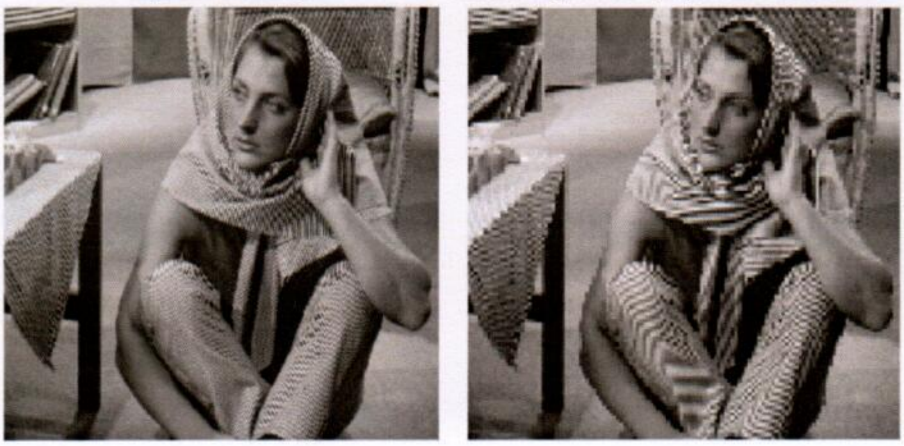
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

(c)
以 (0,0) 旋轉，公式改變

2. (10 points) Following question is about aliasing. PPT 4-A p22, 23.
   (a) (5 points) Describe the sampling theorem and explain why aliasing would occur if the chosen sampling rate is inappropriate.
   (b) (5 points) How to prevent aliasing problem when shrinking an image.

3. (10 points) Following question is about image processing. PPT 4-A p38.
   (a) (5 points) Explain the effect of reducing the sampling rate to one-fourth in the original Barbara image shown below. What causes these differences?

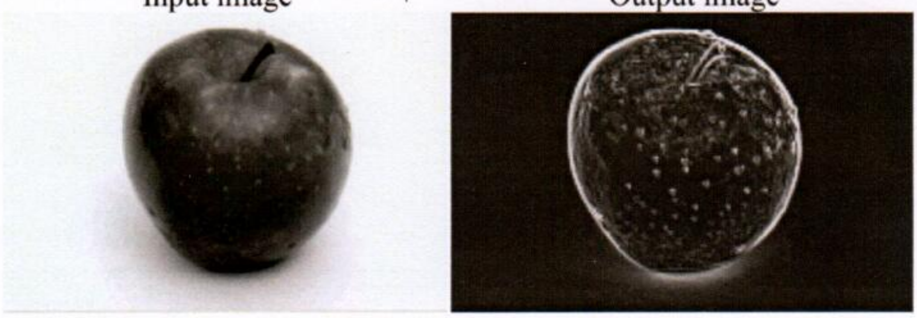
Original Barbara image Barbara image with sampling rate reduced to one-fourth



   (b) (5 points) Considering the processed (resulting) image on the right, what would be the most likely (3 × 3) spatial filter applied to the input image on the left, specify its mask.

laplacian, sobel?

Input image **Output image**



4. (20 points) Assume you are given an image that suffers from the following problems related to image quality.

    1. The image does not have enough contrast. Most areas in the image appear to be too bright. 對比不夠、太白.
    2. The structures and boundaries in the image are blurred and thus it is hard to see the details of objects in the image. 看不到細節 邊緣.
    3. There are random sparse black spots (pepper noise) that seem to be caused by some electronics noises. 有黑點

    You are asked to propose a system that use techniques you have learned in this class to improve the overall image quality. Note that we don't want the result be too artificial. Choose the method carefully. 沒有特定答案

    Please design a conceptual diagram for a quality enhancement system that addresses all the problems mentioned above. Provide justifications for the use of each component and the specific order you adopt in combining different components. Try to provide as much information as needed. For example, if you use contrast stretching, specify the shape of the intensity mapping function. If you use sharpening filters, specify the specific type of filter you will use.

1. 有 noise ⇒ 先 denoise ⇒ mean / median filter

2. 邊緣 histogram. (hw2)
unsharp mask. ⇒ 先 blur 相減找 mask.

3.

5. (10 points) Following question is about Nyquist Rate.
    (a) (5 points) What is the definition of Nyquist Rate? 最高 Sampling rate × 2
    (b) (5 points) What is the Nyquist Rate of $f(t) = \cos(2\pi nt)$?

    $f = n \Rightarrow$ nyquist rate $= 2n$

一維

6. (20 points) Laplacian operator uses the 2nd order derivative, $\nabla^2 f = \partial^2 f/\partial x^2$, to estimate the magnitude of the spatial variation at a point. A popular method based on Laplacian for enhancing the image quality is called "high-frequency emphasis". It can be modeled by the following equation:

$$g = f - \nabla^2 f \tag{1}$$

(a) (5 points) Laplacian operator, $\nabla^2 f$ is often implemented in the spatial domain with the following mask:

$$\begin{bmatrix} 1 & -2 & 1 \end{bmatrix} \tag{2}$$

Note the origin corresponds to the center of the mask. Derive the corresponding spatial-domain mask that can be used to compute g.

(b) (10 points) We can model the high-frequency emphasis process as a linear filter like the one shown below:

$$f \longrightarrow \boxed{h} \longrightarrow g$$

二維

$f \xrightarrow{DFT} H(u,v) f(u,v)$

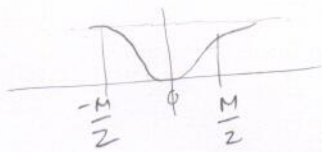
$\frac{1}{M}\sum_{x=0}^{M-1}$ ...... $e^{j\theta}$

Derive the Discrete Fourier Transform of the filter, h.

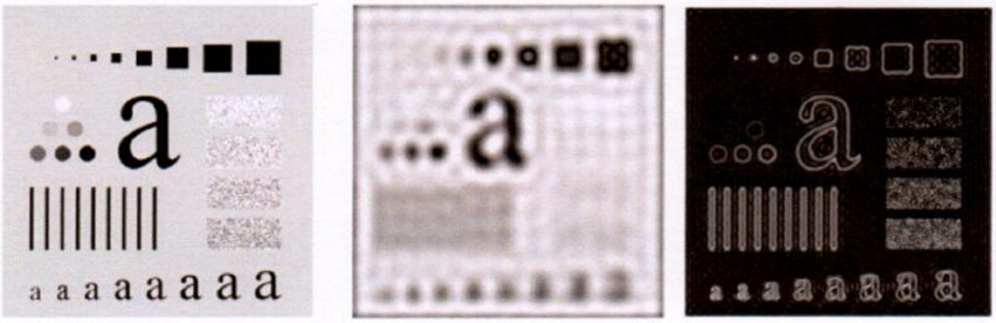
整理成 H(u) f(u)、答案回答 H() 即可

(c) (5 points) Plot the spectrum and explain that indeed it is a good approximation of the spectrum of the Laplacian operation in the frequency domain.

H(u)



7. (10 points) Consider the 3 images given below:



The left image is the original image, and the next two are processed images. Explain what type of filter have produced the effect in these two image

4-B. P3.7

ideal

ringing effect

4-B. P19,20

butterworth, gaussian.

為何可以解決 ringing effect

→ 轉換過程較smooth，故不會有ringing effect