EIE4512 - Digital Image Processing – Homework #1

Instructor: Prof. Zhen Li

Due on 03/08/2019 17:00 pm

Written exercises

problem 1

A common measure of transmission for digital data is the *baud rate*, defined as the number of bits transmitted per second. Generally, transmission is accomplished

in packets consisting of a start bit, a byte (8 bits) of information, and a stop bit. Using these facts, answer the following:

(a) How many minutes would it take to transmit a 1024×1024 image with 256 intensity levels using a 56K baud modem?

(b) What would the time be at 3000K baud, a representative medium speed of a phone DSL (Digital Subscriber Line) connection?

problem 2

Consider the two image subsets, S_1 and S_2, shown in the following figure. For $V = \{1\}$, determine whether these two subsets are (a) 4-adjacent, (b) 8-adjacent, or (c) m-adjacent.

		S_1				S_2			
0	0	0	0	0	0	0	1	1	0
1	0	0	1	0	0	1	0	0	1
1	0	0	1	0	1	1	0	0	0
0	0	1	1	1	0	0	0	0	0
0	0	1	1	1	0	0	1	1	1

problem 3

(a) Give a continuous function for implementing the contrast stretching transformation shown in Fig. 3.2(a). In addition to m, your function must include a parameter, E, for controlling the slope of the function as it transitions from low to high intensity values. Your function should be normalized so that its minimum and maximum values are 0 and 1, respectively.

(b) Sketch a family of transformations as a function of parameter E, for a fixed value $m = L/2$, where L is the number of intensity levels in the image.

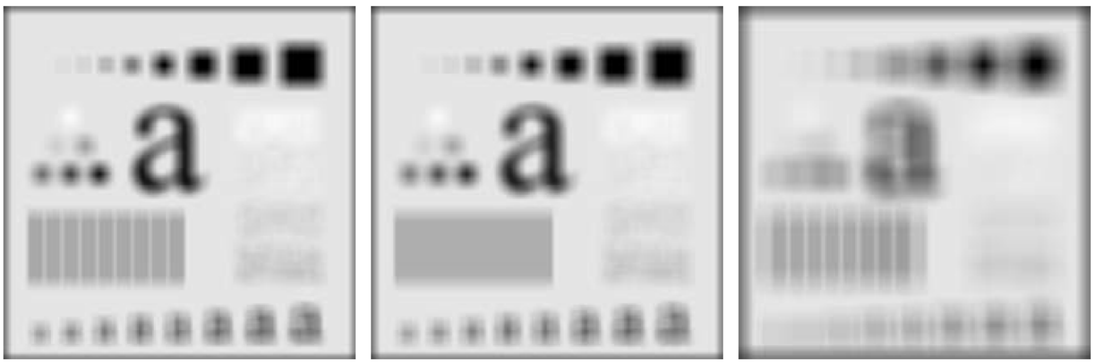
(c) What is the smallest value of E that will make your function *effectively* perform as the function in Fig. 3.2(b)? In other words, your function does not have to be identical to Fig. 3.2(b). It just has to yield the same result of producing a binary image. Assume that you are working with 8-bit images, and let $m = 128$. Let C denote the smallest positive number representable in the computer you are using.

problem 4

Suppose that a digital image is subjected to histogram equalization. Show that a second pass of histogram equalization (on the histogram-equalized image) will produce exactly the same result as the first pass.

problem 5

The three images shown were blurred using square averaging masks of sizes $n = 23$, 25, and 45, respectively. The vertical bars on the left lower part of (a) and (c) are 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)**

problem 6

Based on Eq. (3.6-1), one approach for approximating a discrete derivative in 2-D is based on computing differences of the form $f(x+1, y) - f(x, y)$ and $f(x, y+1) - f(x, y)$.

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

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

problem 7

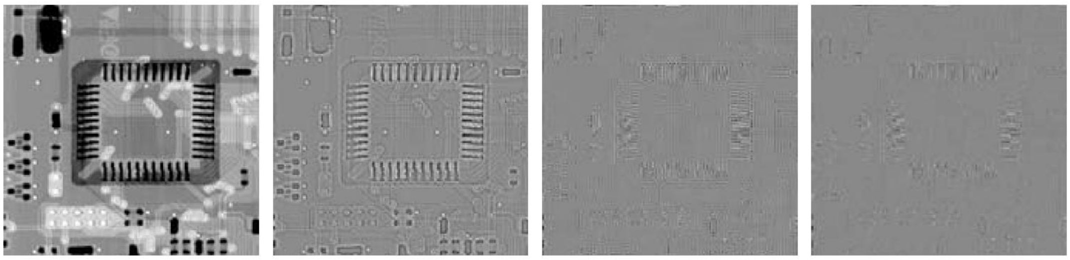
Consider the images shown. The image on the right was obtained by: (a) multiplying the image on the left by $(-1)^{x+y}$; (b) computing the DFT; (c) taking the complex conjugate of the transform; (d) computing the inverse DFT; and (e) multiplying the real part of the result by $(-1)^{x+y}$. Explain (mathematically) why the image on the right appears as it does.

problem 8

Consider the sequence of images shown. The image on the left is a segment of an X-ray image of a commercial printed circuit board. The images following it are, respectively, the results of subjecting the image to 1, 10, and 100 passes of a Gaussian highpass filter with $D_0 = 30$. The images are of size 330×334 pixels, with each pixel being represented by 8 bits of gray. The images were scaled for display, but this has no effect on the problem statement.

(a) It appears from the images that changes will cease to take place after some finite number of passes. Show whether or not this in fact is the case. You may ignore computational round-off errors. Let $c_{\min}$ denote the smallest positive number representable in the machine in which the proposed experiment will be conducted.

(b) If you determined in (a) that changes would cease after a finite number of iterations, determine the minimum value of that number.



Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.

Matlab exercises

1. Filtered Noise

(a) Consider the filter with Fourier transform

$$H(u, v) = \frac{1}{u^2 + v^2}$$

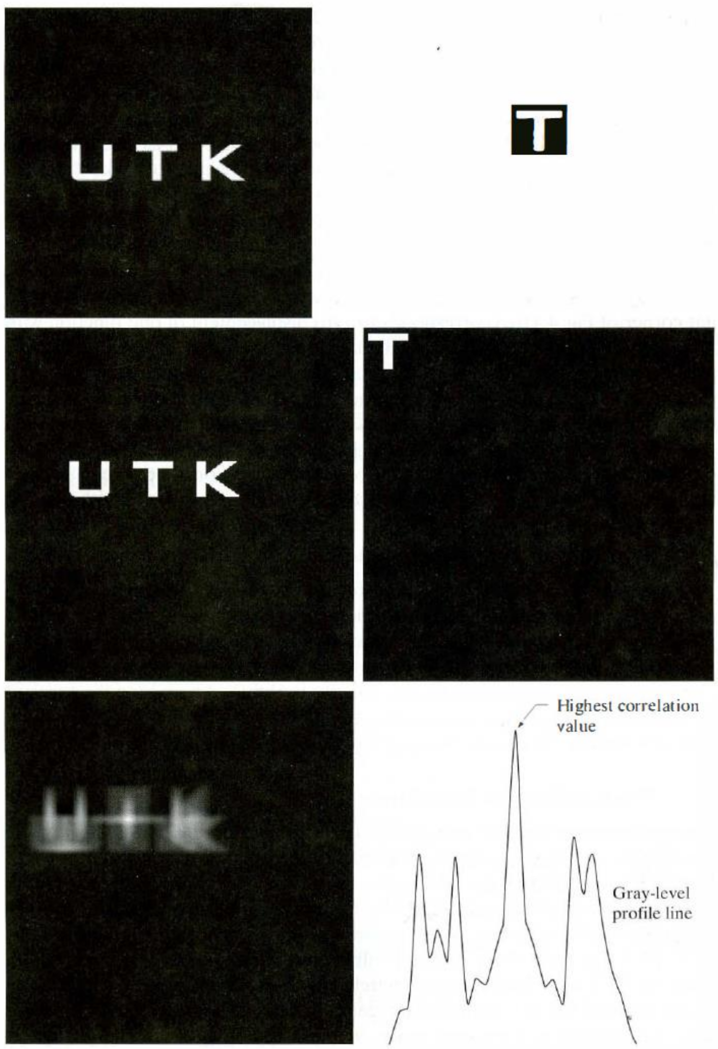
on the interval $[-127, 128] \times [-127, 128]$. This is known as a $1/f^2$ transfer function. Since it blows up at the origin, replace that value with zero. Apply this filter to a 256 × 256 image of normally distributed random noise (use **randn**). For practical reasons, it is best to perform this operation in the frequency domain. Hint: you will need to use **meshgrid**, **fft2**, **ifft2**, and **fftshift**. Also, due to numerical error, you will need to use real to look at the real part of the filtered image in the spatial domain.

(b) Display the filtered image along with the original noise image. Quite remarkably, the filtered image should look like a "natural" texture, such as clouds or terrain. What does this suggest about the statistics of natural images vs. that of images of manmade objects?

Things to turn in:

- Code listing for part 1a.
- Printout and written answer for part 1b.

2. Filtering in the Frequency Domain



a b
c d
e f

FIGURE 4.41 (a) Image. (b) Template. (c) and (d) Padded images. (e) Correlation function displayed as an image. (f) Horizontal profile line through the highest value in (e), showing the point at which the best match took place.

EXAMPLE 4.11: Image correlation.

■ Figure 4.41 shows a simple illustration of image padding and correlation. Figure 4.41(a) is the image and Fig. 4.41(b) is the template. The image and template are of size 256×256 and 38×42 pixels, respectively. In this case, $A = B = 256$, $C = 38$, and $D = 42$. This gives the minimum values for the extended functions: $P = A + C - 1 = 293$ and $Q = B + D - 1 = 297$. We

(a) Write an m-file to reproduce Figure 4.41(a-f) using Frequency domain filtering. Note: the Matlab command for the complex conjugate is `conj`.

(b) Repeat the previous step using operations in the spatial domain and show that the resultsare the same. Hint: use `conv2` and `rot90`

Things to turn in:

- Code listing for parts 2a and 2b.
- Printouts of program output for parts 2a and 2b.

3. Histogram Equalization

Click here to download the input image or in the assignment folder.

(a) Write an m-file to show picture histogram. Hint: use **imhist**

(b) Do histogram equalization on the input image, and compare the histogram difference between input image and output image. Hint: use **histeq**

Things to turn in:

- Code listing for parts 3a and 3b.
- Printouts of program output for parts 3a and 3b.