ECEN 447, Fall 2021

Texas A&M University

Electrical and Computer Engineering Department

Dr. Raffaella Righetti

TA: Songyuan Tang

Homework #5

Topic: Image restoration

Due on November 11, 2021 6:29 pm

Instructions for the hand-written homework:

For the homework, you will be asked some basic concepts covered in your lectures, or to solve some problems based on a certain application in image processing. Most of the problems will be adapted from those solved during the lab. Please make sure to include necessary steps in your solutions. And we will evaluate your understanding of the problem in addition to the final results.

How to submit:

For hand-written homework problems, submit them on CANVAS. Please number the problems you are solving and clearly include steps necessary in your solutions.

1) Total Num pixels 1000000
1/4 of each intensity value
250000
1 32 64 128 Intensity

PROBLEM (1)

Given an image as shown in Fig. 1-1:

(1). Sketch its histogram. As for the intensity values of the four patches, they are 1, 32, 64, 128 as the brightness increases.

Gaussian centered at each Intensity Value

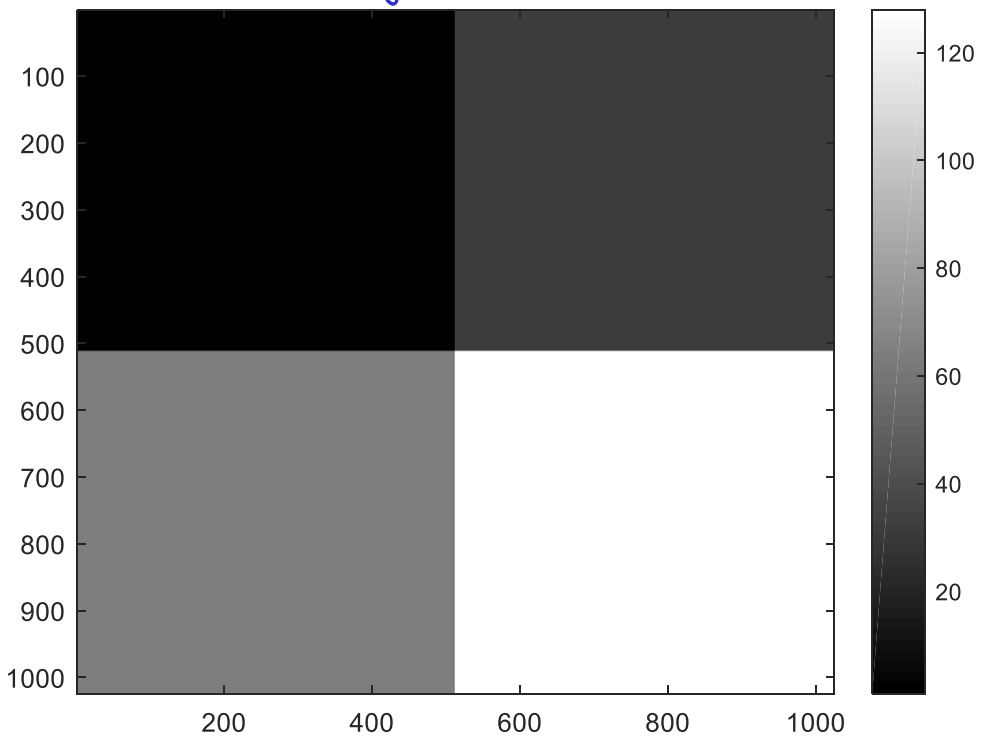
2)

1 32 64 128 Intensity Value

(2). Add Gaussian noise ($\mu = 0, \sigma = 1$) to the image, briefly sketch the histogram again.

(3). How will the local peaks (if there are multiple) in the histogram you obtain in (2) change (in both x- and y- directions) if σ increases? Briefly justify your claim.

3) The locations will stay at the same X positions but the y's will lower.



PROBLEM (2)

Load "CosineWave.mat" (i) in Matlab,

(a) Please pad it with 0s at its left and top (ii); right and bottom (iii); and all four borders evenly (iv). After you finish padding, the image size should become twice of its original size. You can try the command "padarray" in Matlab. Display the resulting images.

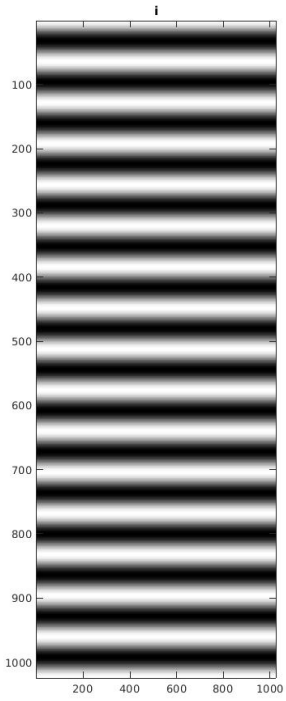
(b) Perform 2D Fourier Transform of images (i-iv), and display their magnitudes after shifting the spectrum to center the zero-frequency component. What is the difference between the transform of (i) and that of other images? What similarity do you find among the transforms of (ii-iv)?

(c) Assuming the sampling frequency to be 1 Hz along the vertical direction, can you please estimate the frequency of the original cosine wave pattern based on the display of (i) in (b) (if you are not able to recognize any pattern from (i) in the frequency domain, try to focus on the locality you expect to see the spectrum and zoom in)?

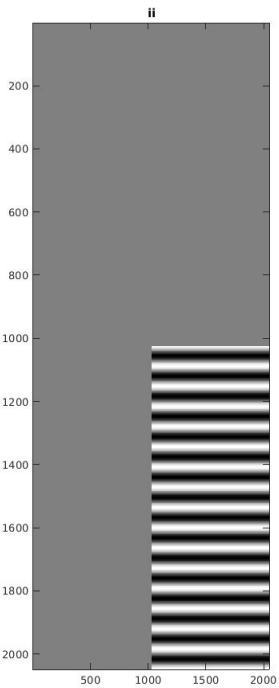
Solution Next page

Images Produced via Matlab

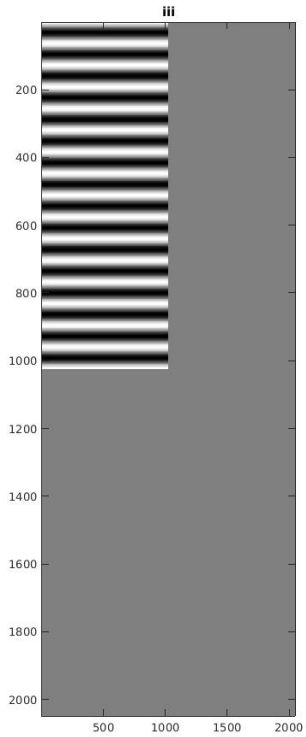
Results A



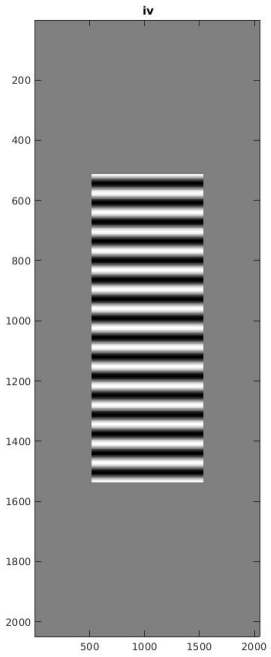
I



II



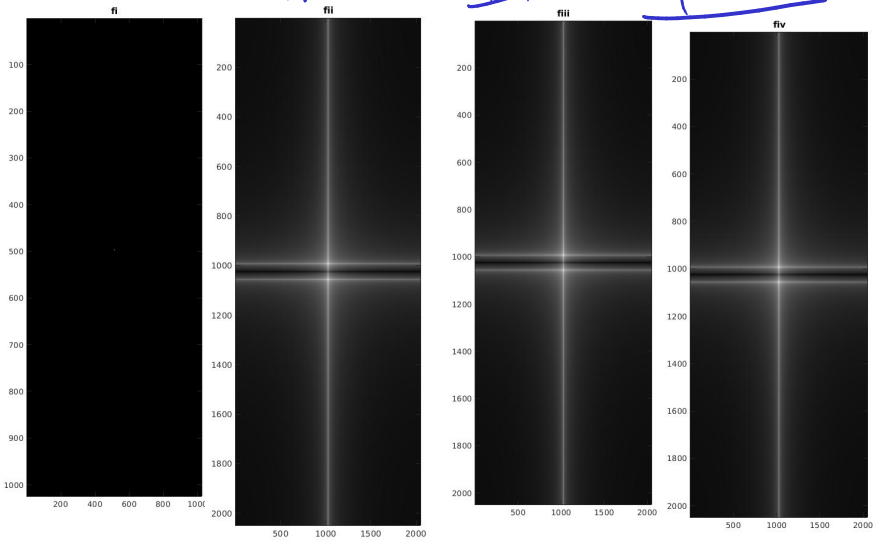
iii



iV

Frequency Images

I II III IV

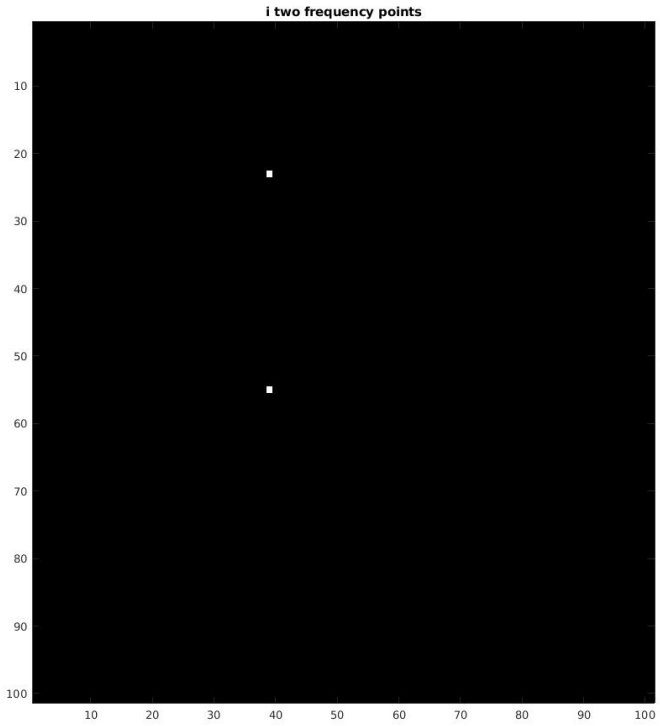


All the others range over all frequencies.

The other transforms are identical.

Band limited around the origin

c)



Two isolated frequency impulses make up the signal.

PROBLEM (3)

Consider a linear, position-invariant image degradation system with the impulse response $h(x-\alpha, y-\beta) = e^{-[(x-\alpha)^2+(y-\beta)^2]}$, suppose that the input to the system is an image consisting of a line of infinitesimal width modeled by $f(x,y) = \delta(x-a) + \delta(x-b)$, where δ is an impulse and $a \neq b$. Assuming no noise:

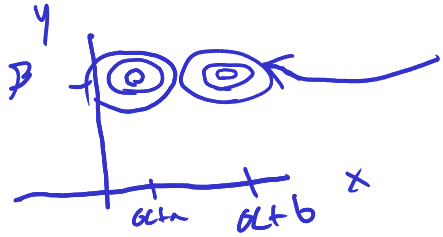
(1) Please calculate the expression of the output (line) image $g(x,y)$.

(2) Based on your calculation, please briefly sketch $g(x,y)$.

(3) What will happen if a and b become closer? You can show the difference by sketch again, but be sure to clearly indicate possible changes you observe.

1) $g(x,y) = e^{-(x-\alpha-a)^2-(y-\beta)^2} + e^{-(x-\alpha-b)^2-(y-\beta)^2}$

2)



Both of the are gaussians in value 3rd dimension of height thus provide a better representation.

3

More overlap between them when a-b this become a single gaussian of double magnitude.