Project 5
Digital Image Processing
CSCE 4240/5225 – Spring 2022
Distributed: Thursday, March 31
Due: Friday, April 18

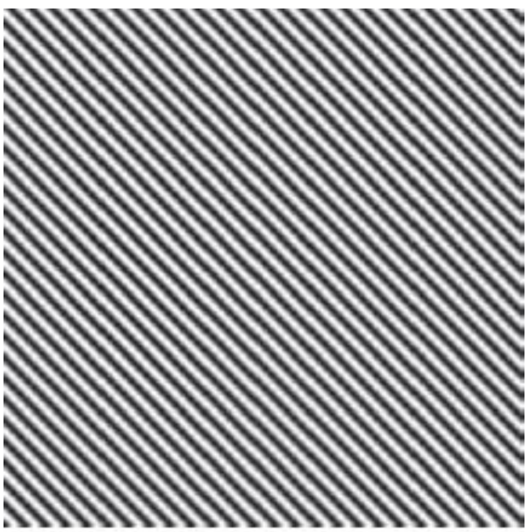
[Solutions to this assignment must be submitted via the CANVAS web site prior to midnight on the due date. It may be submitted a day late with NO penalty. It may be submitted the second day after the due date but penalized 10 pts. This is an assignment to be performed by individuals, not groups. No one has my permission to copy a solution from another or to allow another to copy from his/her solution. Such behavior will be a grading criterion and, if found, result in a ZERO grade for this assignment.]

Purpose. To instruct by example two topics: (1) The representation of the frequency domain in phase angle-magnitude format; (2) Notch filters

What to do

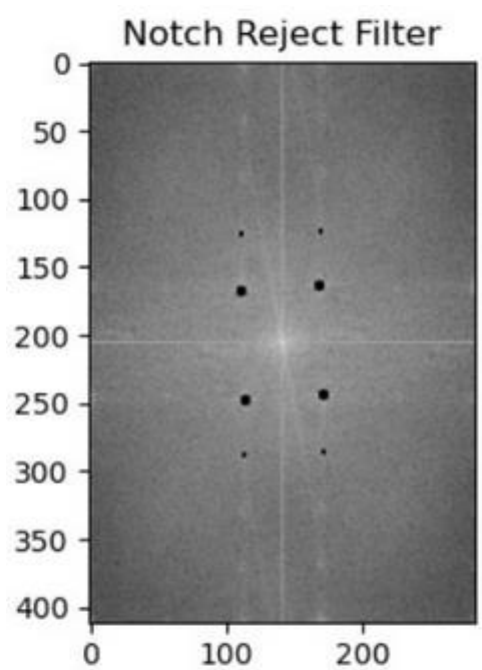
Part I: *<u>Periodic Noise Reduction Using a Notch Filter</u>*

(a) Design and implement a function that constructs a spatial image that consists of eight or more periods of a cosine (or sine) wave. The inputs to the function must include the amplitude, A. The grating should propagate in the direction of 45^{O}. The grating should appear similar to the one on the left. The size should be 512 x 512 or 256 x 256.



(b) Use the image DIPbook_cover included with the assignment on the CANVAS website. Add sinusoidal noise to it. The value of A must be high enough for the noise to be clearly visible. in the image.

(c) Compute the spectrum of the image, which is used to manually determine the position of the components generating periodic noise.



(d) Filter the image using a notch filter of the form shown on the right. Alternatively, you may use one similar to Fig. 5.18(c) within the text.

> Strictly speaking, the illustration on the right is not a notch filter. It is the results of applying a notch filter to the DFT of an image then displaying the spectrum. You will need to imagine the filter that when multiplied by the DFT of the image produces a result as shown.

Final Exam: Thursday May 12
10:30 a.m. - 12:30 p.m.

Part II: *<u>The [magnitude, θ] representation of the frequency domain</u>*
Begin by obtaining the [magnitude, Θ] representation of the image in file DIPbook_cover. In general, independent of images, a complex number is representable as *F(u,v) = R(u,v) + j× I(u,v)* where j is the imaginary basis (square root of -1). The magnitude (a.k.a., spectrum) is $M(u,v) = \sqrt{[R(u,v)]^2 + [I(u,v]^2}$. (The magnitude is also known as the frequency spectrum.) The other component, the phase angle, is $\theta(u,v) = \ tan^{-1}\left[\frac{I(u,v)}{R(u,v)}\right]$. Assume the the Fourier transform is (*f(x,y) => F(u,v)*). For each component of F(u,v), compute the magnitude and phase angle.

Display the inverse transform of the magnitude, *M(u,v)*. Next, display the inverse transform of the phase angle matrix, *θ(u,v)* as the imaginary numbers of a frequency spectrum for which the real part is all one's. One first must convert the phase angles to complex numbers. One does so by multiplying each by *j*, that is *(j ×Θ).* [Hint: in Matlab, the keyword, *1j*, is the imaginary basis.]

What to Hand In

<u>For Part I:</u> **Submit to CANVAS**. ("Project 5 Part I")

(1) the code,
(2) the original spatial image,
(3) the spectrum which we have informally called the Fourier transform of the original image,
(4) the spectrum after the Fourier transform has been multiplied by the notch filter,
(5) the spatial image following the application of the notch filter in the frequency domain, and
(6) an image depicting the notch filter.

Examine Fig. 4.64 or Fig. 5.16 in the textbook for an example of a good illustration of results. CAREFULLY LABEL THE IMAGES.

<u>For Part II:</u> **Submit to CANVAS**. ("Project 5 Part II")

(1) The code,
(2) The original spatial image,
(3) The spectrum of the original image,
(4) the spatial view of the magnitude array, (inverse FT of *M(u,v)*),
(5) the spatial view of the phase angle array, (inverse FT of j×*θ(u,v)*).

Examine Fig. 4.26 in the textbook for an example of a good illustration of results. CAREFULLY LABEL THE IMAGES.

What to expect

The spatial form of the magnitude array will not show much of anything – just a cloudy appearance. The spatial form of the phase angle array should show faintly the original spatial image. If not, not to worry. It could be the vagaries of the arithmetic used by your system – dynamic ranging, etc. You might consider adjusting the brightness or contrast (gamma correction or equalization) but it is not necessary that you do so.

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