Assignment #3

Image Enhancement in Frequency Domain!

How TA evaluates your assignments:

Report: half of your score will be graded proportional to the quality of your report. You should provide a distinct section for each problem, include the desired outputs and explain what you've done. Don't forget to discuss your results as well. Note that in your reports, all your figures must have captions. It is not necessary to accommodate your source codes in your reports unless you want to refer to them. Compactness, expressiveness and neatness are of high importance.

Source Code: create an m-file for any problem and write all your codes there. If a problem consists of several sub-problems, separate them by comments in your code. Finally, name your m-files according to the number of the problems.

For evaluating your codes, TA creates two empty folders just beside your m-files, named as "input" and "output" (in the same directory). Then, he copies the input materials into the "input" folder and executes your m-files. Next, the output files will be checked in the "output" folder. Therefore, write your codes so as to load input files from an "input" folder and save the output files in an "output" folder. The exact name of the input and output files will be provided in the problem descriptions.

You can use MATLAB built-in functions in your implementations except for the cases in which the allowance has been explicitly revoked.

What to hand in:

You must submit your report (.pdf), source codes (m-files) and output files for each assignment. Zip all your files into an archive file and use the following template to name it:

HW3_XXXXX.zip

where XXXXX must be replaced with your student ID. Your file size must not be bigger than 20MB. If there is any question, don't hesitate to contact us through nasiri.hamid@gmail.com, s.izadi@live.com

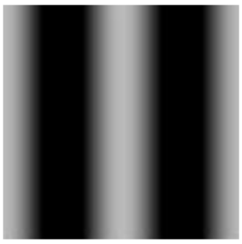
The Due Date for This Assignment is: Apr. 30th

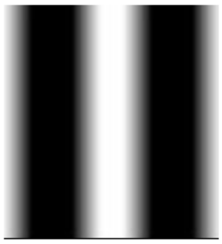
1. Fig.1 shows a sinusoidal pattern in the spatial domain (left) and its corresponding representation in the frequency domain. According to the provided sample and your own knowledge about the Fourier transform, generate the following sinusoidal patterns by initializing appropriate entries of a square matrix and applying **inverse Fourier transform** on it. For each pattern, explain which entries must be manipulated and where their effects show up. Note that all images are of size 100x100. Name the resultant images as "sin_patt_a.bmp" to "sin_patt_s.bmp" and write them into output directory.

Figure 1. A sinusoidal pattern and its representation in frequency domain

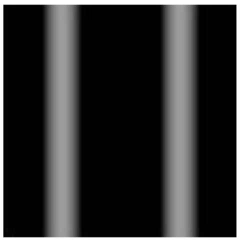
(a) (b) (c)


(d)

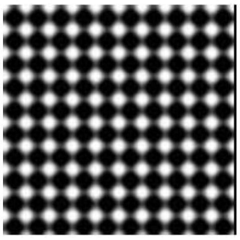

(e)

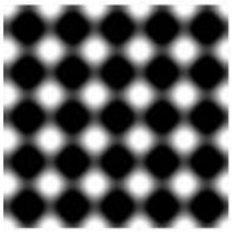

(f)

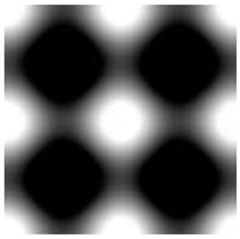

(g)

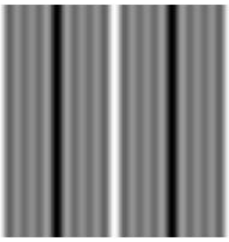

(h)


(i)


(j)


(k)

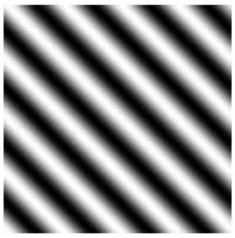

(l)

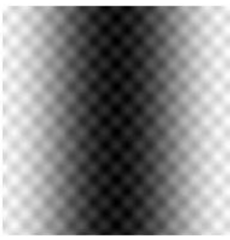

(m)

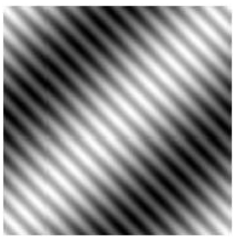

(n)


(o)


(p)


(q)


(r)


(s)

2. Design and implement some meaningful experiments to explain the behavior of Fourier transform for the following variations:

- Scale
- Rotation
- Translation

Justify the results clearly. Note that your experiments must be as informative and expressive as possible. Simple and intuitive experiments are of high interest.

3. Find the Fourier transform of the following function and data by hand. Include sufficient and significant calculation steps in your report.

a. $f(x,y) = \sin 6\pi x - \cos 8\pi y$

b. Apply discrete Fourier transform on the following data. $\{1,2,3,4\}$.

c. Apply inverse discrete Fourier Transform on the results of the part **b**. Explain your observations.

d.

-0.4444	-0.6268	-0.1409
0.4444	0.6268	0.1409
0.4444	0.6268	0.1409

4. In this problem, you are supposed to get familiar with image enhancement in the frequency domain. Provide well-commented codes and apply zero-padding before any operation, if necessary. <u>You are not allowed to use built-in MATLAB functions for frequency-based filtering in this problem.</u>

a. Implement **Ideal, Butterfly** and **Gaussian low-pass** filters in the frequency domain. Verify your code on "taxiDriver.bmp" for different values of the frequency cutoffs and filter-specific parameters, and include some of them in your report. Do you see any ringing effect? For which method and for what frequency cutoffs? Why? Provide a comprehensive comparison of qualitative performance between all three methods. Using different settings of parameters, name the best result of each method as "TaxiDriver_ILPF_best.bmp", "TaxiDriver_BLPF_best.bmp" and "TaxiDriver_GLPF_best.bmp" respectively, and save them into the output directory.

b. Apply Gaussian mean filter on the provided input image in the spatial domain. Change the parameters to get the best performance and compare the best resultant image with those of methods in part **a** (the best results) in terms of qualitative performance and runtime execution. Include the results in your report.

c. Implement Ideal, Butterfly and **Gaussian high-pass** filters in the frequency domain. Verify your code on "ball.bmp" for different values of filter-specific parameters and include some of them in your report. Provide a comprehensive comparison of qualitative performance between all three methods. Using different settings of parameters, name the best results of each method as "ball_IHPF_best.bmp", "ball_BHPF_best.bmp" and "ball_GHPF_best.bmp" respectively, and save them into the output directory.

5. Frequency filters are quite useful when processing parts of an image which can be associated with certain frequencies. The image "house.bmp" shows an image in which any part of the house is made of stripes of a different frequency and orientation.

a. Computer the Fourier transform of the image and show it in your report. Explain the correspondences between the spatial characteristics and main peaks in frequency domain.

b. we can smooth the vertical stripes (i.e. those components which make up the wall in the spatial domain image) by multiplying the Fourier image with a frequency mask. In so doing, we can exploit the provided mask "mask_ver.bmp". Perform this task and include the result in your report. Explain why the provided mask is appropriate for such a task. Repeat the preceding scheme for at least two other components of the house and include the results in your report (design appropriate masks on your own knowledge)

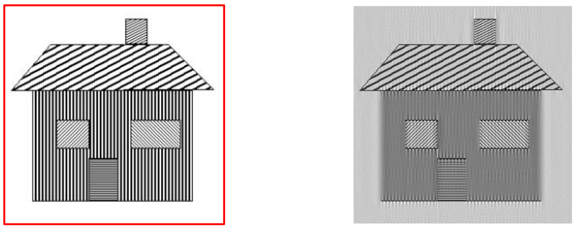


Figure 6.

6. Some blurred images can be sharpened through amplifying the high frequencies of the images. To do so, one may suggest to use the following filter:

$$F(u_i) = 0.99 \times \exp\left(-\frac{u_i^2}{2\sigma^2}\right) + 0.01$$

Where σ is the width of the filter and u_i is the i^{th} frequency component.

a. Describe the rationale behind this filter and explain why it would be helpful in image de-blurring/sharpening?

b. Design a 2D filter to sharpen 'Blur.bmp' image. Find the appropriate value for sigma. Report the found value for sigma and the output of enhancement. Justify your results.

c. Is the proposed filter useful for deblurring all sorts of blurred image? If no, explain why.

Good Luck,

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