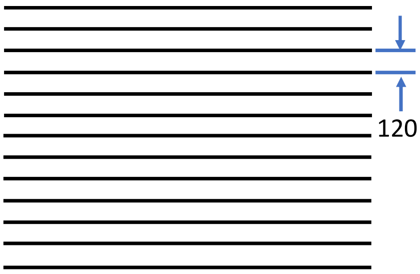
Homework #3

2023 EE402
Digital Image Processing

1. (60 pts) The size of the strip image is 2000 by 2000, and the pixel distance (Δx and Δy) is 20 µm. Assume that the width of the strips is very thin, so that it can be considered as an impulse train along the vertical axis. The distance between the strips is 120 µm.



   (a) Draw the 2D frequency spectrum of the image, explain why. (10 pts)
   (b) What is the maximum frequency of the 2D frequency spectrum? Indicate the frequencies of the principal spectral components in the spectral image. Assume that the spectrum was centered; the center is the zero frequency. (15 pts)
   (c) You want to remove all the frequency components except DC. How to do this? Explain the method by using the equations based on a Butterworth shaped transfer function. (15 pts)
   (d) What happen to the image in the spatial domain after (c), i.e., rejection of all the frequency components except DC. (10 pts)
   (e) If the strip image is rotated 45° counterclockwise, draw the 2D frequency spectrum of the rotated image. Explain why (10 pts).

2. (80 pts) For edge detection, you may use a high pass filter in either the spatial or frequency domain.

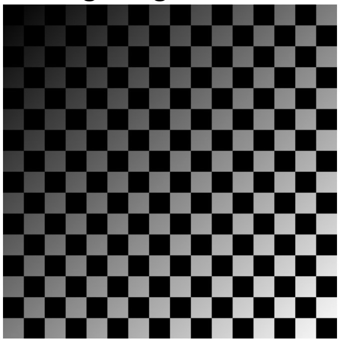
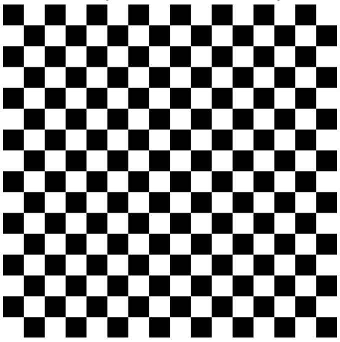
$$h = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

   (a) Write a program to obtain the edge information of the moon image (i.e., moon-blurry.tif) by the filtering in the spatial domain. Use the Laplacian kernel including the diagonal terms. Show the resultant image. (30 pts)
   (b) Write a program to obtain the edge information of the moon image by the filtering in the frequency domain. You need to obtain the transfer function of the Laplacian

kernel including the diagonal terms. Show the transfer function and resultant image. (40 pts)

(c) Are the two resultant images the same or different? Explain the reason. (10 pts)

3. (70 pts) A useful application of lowpass filtering is correcting images that exhibit a shading pattern caused by nonuniform illumination, often referred to as an illumination gradient. The following image on the left is an example of such a phenomenon.

When the illumination gradient varies slowly (i.e., it is a low-frequency spatial pattern), it is possible to estimate it using aggressive lowpass filtering. The effect of nonuniform illumination can then be corrected by dividing the image by the illumination pattern. The image on the right is an example of using the approach.

(a) Write a function, **ShadingCorrection.m**, that implements the method just described. Use Gaussian lowpass filtering and 'symmetric' padding. Read the image 'checkerboard1024-shaded.tif' and use your function to generate a result that looks approximately like the preceding image on the right. **Display the shading pattern computed by your function and the corrected image obtained using the pattern**.

(b) What percentage of the padded input image power was removed using the Gaussian lowpass filter to obtain the corrected image? Explain how to obtain the value. (20 pts)