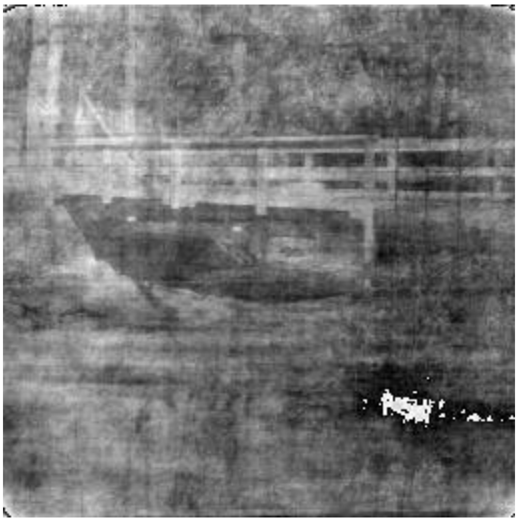
CV 2022 Take Home Exam (Due 4/21/2022, 09:10am)

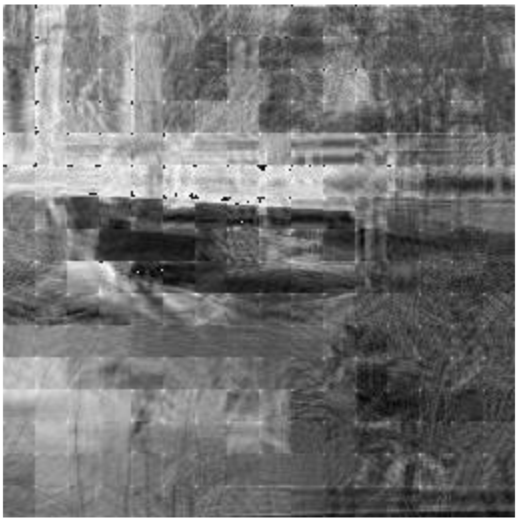
1. Given a 256x256 image: (15%)
   http://www.cs.nccu.edu.tw/~whliao/cv2022/bridge.jpg
   (a) Perform the Fourier transform, keeping only 1/4 largest coefficients, and perform inverse transform to obtain image A.
   (b) Divide the image into 256 16x16 blocks. Perform Fourier Transform on each block, keeping only 1/4 largest coefficients in each block, and take inverse transform to obtain image B.
   (c) Reduce the size of the original image to 128x128 by sub-sampling or averaging. Perform Fourier Transform on the 128x128 image. Zero-pad the coefficient matrix to a 256x256 array. Then perform inverse transform to obtain image C.

   Compute and compare the mean square error between (image, image A), (image, image B), and (image, image C):

   a.



b.



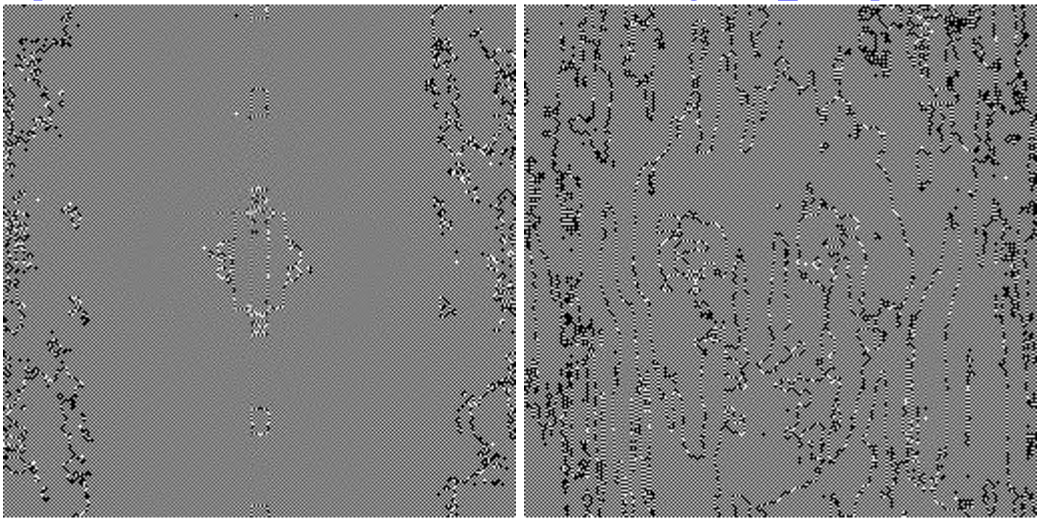
c.

297.2347869873047

248.05609130859375

323.7835693359375

2. Verify Fig 4.27 (page 249, DIP 3e). In other words, exchange the magnitude and phase of the discrete Fourier Transform of the following two images and show the results. (10%)
http://www.cs.nccu.edu.tw/~whliao/cv2022/Fig0427_a.bmp
http://www.cs.nccu.edu.tw/~whliao/cv2022/Fig0424_a.bmp



3. During acquisition, an image undergoes uniform linear motion in the vertical direction for a time interval T_1. The direction of motion then switches to the horizontal direction for a time interval T_2. Assuming that the time it takes for the camera to change direction is negligible, and the shutter opening closing times are also negligible, derive the expression for the blurring function H(u,v). (10%)

$$H(u,v) = H_x(u,v)\, H_y(u,v)$$

$$= \frac{T_1}{\pi u a_x} \sin(\pi u a_x)\, e^{-j\pi u a_x} \times \frac{T_2}{\pi v a_y} \sin(\pi v a_y)\, e^{-j\pi v a_y}$$

$$= \frac{T_1 T_2}{\pi^2 u v a_x a_y} \sin(\pi u a_x) \sin(\pi v a_y)\, e^{-j\pi(u a_x + v a_y)}$$

$$= \frac{T_1 T_2}{\pi^2 u v a_x a_y} \frac{\cos(\pi(u a_x - v a_y)) - \cos(\pi(u a_x + v a_y))}{2}\, e^{-j\pi(u a_x + v a_y)}$$

4. [Limiting Effects] (a) Discuss the limiting effect of repeatedly applying a Gaussian low-pass filter to a digital image using frequency domain analysis. (Ignore border effects). (5%) (b) Repeat (a) using median filter in the spatial domain. (5%). Discuss your findings. Hint for (a):

a. The pic will have black spots randomly show in the all-white picture
b. Some white part of the picture such as baluster will go darker
   If I change the variable in the median function, the photo will have an obvious line (like water flow) to divide the picture.