Principles and Applications of Digital Image Processing

【Fall, 2021】

Homework 4

Part 1: (25%)

Design a computer program to perform Fourier transform of an image using FFT. You may use FFT function source code available on the CEIBA course website or FFT function of OpenCV library. The image spectrum obtained after Fourier transform could be further processed using the following method to achieve better display. Beside image spectrum, also display the image phase angle with your program.

F_{MIN} = LOG(1+ABS(F_{min})) F_{min} is the minimum value of the F(u,v) spectrum

F_{MAX} = LOG(1+ABS(F_{max})) F_{max} is the maximum value of the F(u,v) spectrum

$Y_{NEW}(u,v) = G*[LOG(1+ABS(F(u,v))) - F_{MIN}]/[F_{MAX} - F_{MIN}]$

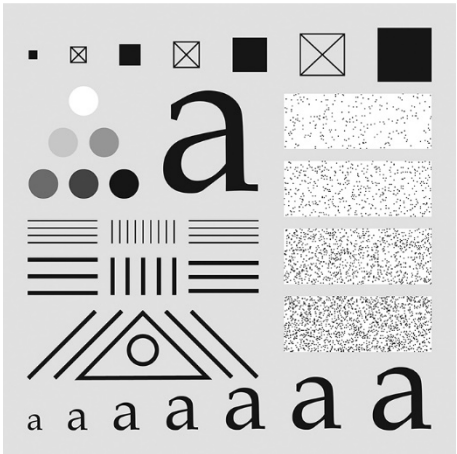
where G is the highest gray level in an image. (G = 255 for most cases)

Is there any difference between the original image and the processed image after forward Fourier transform and inverse Fourier transform using your program? Examine and discuss your result.

Make an analysis of the effect of image size on the processing time of your Fourier transform program.

Part 2: (25%)

Design a program for highpass and lowpass filtering of images using (1) Ideal filter; (2) Butterworth filter; (3) Gaussian filter. Test your program with the following image and discuss the effect of cut-off frequency on the processed image.



Part 3: (25%)

Design an image processing program for homomorphic filtering as described in Section 4.9 in our textbook. Your program should have a user-friendly interface allowing flexible adjustment of three parameters γ_H, γ_L, and D_0 defined in equation (4-147). Discuss the effect of these parameters on the processed image.

Part 4: (25%)

Design an image processing program to create a motion blurred image as shown in Figure 5.26b. Then apply a 2-D frequency domain inverse filter and Wiener filter to this blurred image, respectively. Comment on the performance of the two filters for removing motion blur. To compare the performance of the two filters, you may compare the processed images with the original unblurred image by image subtraction.

Add a zero-mean white Gaussian noise to the motion blurred image with variance $\sigma = 20$. Restore the image with inverse filter and Wiener filter, respectively. Comment on the simultaneous noise removal and de-blurring abilities of the two filters. Also discuss the effect of noise level on the result of image restoration.

Notes:

1. Please submit your programs and report to the AUTOLAB course website before **Nov. 17 (2:20PM).**
2. Late submission will have a penalty of 10% discount per day of your homework total score toward a maximum of 50% discount. No late submission over five days will be accepted.