ECSE 436A **McGill University**
Prof. Bajcsy **Fall 2016**

Laboratory Assignment 3 (both parts)

Due: Monday, Dec.5 in class

1. Elements of Image Processing

Read-in a compressed jpeg image (baboon.jpg or lena.jpg) into Matlab using *imread('file.jpg')* command. Convert the jpg image to a greyscale in Matlab using the *rgb2gray*, then display it using the *imshow* command.

(a) Sub-sample the image 2:1, 4:1, 8:1 and 16:1. Describe what you observe in the sub-sampled images.

(b) Quantize the greyscale image pixels to 6, 4, 2 and 1 bit per pixel. Can you observe the false contours? Explain why they occur.

(c) Use 'randn' Matlab function to add *Gaussian noise* to the image, so that the SNR is 40 dB, 30, 25, 20, 15, 10, 0, -10 dB, -30 dB Describe the impact of noise on perceptual quality of the image at different SNRs. (Hint : First determine signal power by averaging squares of I(x,y) pixels values.)

(d) Corrupt pixels of your image with i.i.d. *impulsive* noise. Assume the impulse probability is 0.1 percent, 1 percent, 5 percent and 10 percent, respectively, while making the impulse magnitude equal to half of the maximum pixel magnitude. Describe the perceptual impact of this noise on the image and calculate the SNR for different impulse probabilities.

(e) Compare your observations in parts (c) and (d)

2. Signal Processing of 2-Dimensional Signals

(a) Use Matlab's 2-D convolution function to blur your *original image* from Problem 1 by filtering it with a low-pass 2-D filter with impulse response $h[n,m]=1/(N^2)$ for $n\ ,\ m\ =\ 1,2,3,..\ N$. What happens to the details in the image for various values of N, i.e., N = 3, 5, 10 and 20.

(b) Use 3-by-3 and 5-by-5 low-pass filters from part **(a)** to reduce the Gaussian noise effect you observed in problem 1 (c). Alternatively, use 2-D FFT to perform appropriate low-pass filtering in spatial frequency domain. Submit your resulting images. (Hint: Use subplot.)

(c) Remove the impulsive noise from Problem 1 **(d)** using a 3-b-3 and 5-by-5 low-pass filters from part **(a).** Describe if this approach worked and why.

(d) Now implement your own 3-by-3 and 5-by-5 *median filter* to remove the impulsive noise. Consequently, filter the image corrupted by impulsive noise and describe the results.

(e) High-pass the original image using the following filter: h[2,2] = 1, h[1,2]=h[2,1]=h[2,3]=h[3,2] = -1/4, h[n,k]=0 otherwise. What is the perceptual impact of the filtering, i.e., what does the filtered image show?

3. Spatial Frequency Domain and 2-D Fourier Transform

(a) Use 2-D FFT in Matlab to plot the magnitute of the 2-D Fourier transform of the original image. Which frequencies are present in this image.

(b) Redo part **(a)** for synthetic images containing a 2D harmonic spatial signal, an single impulse signal, a constant image and a 'Japanese flag' signal.

(c) Determine the magnitude of the frequency response for filters used in Problem 2(a),(e), describe what you observe. Can you do the same for the median filter from 2(d)? Justify your answers.

(d) Reconstruct the original image from its frequency domain description using magnitude of its 2-D Fourier transform only and setting the phase to be always 0. Describe what you observe

(e) Redo part (d) using reconstruction from *phase-only* information, setting magnitude to a constant.

(f) Explain why your reconstructed image in part (e) is better. (Hint: Use entropy.)

4. Real-Time Images

(a) Using the FPGA board, generate an artificial image of a square of a given radius, then output it onto the computer screen. Use board pins to adjust the radius of the circle.

(b) Make the square move across the computer screen at a speed adjustable by the pins.
(c) Make the square in (b) change its color in time, e.g., cyclically going through the rainbow colors and changing color each second.
(d) In addition to submitting your implementation scripts and observations, demonstrate your implementation to the TA's.