ECE468/CS519: HOMEWORK 3
due 11/03/2017

(30 points) Problem 1

This MATLAB project assignment is about denoising an image corrupted by salt-and-pepper noise. Use the image provided on the class website as uncorrupted original image $f_0(x, y)$.

1) Compute in MATLAB:
   1.1) Random matrix, $t_1(x, y)$, where all elements of $t_1(x, y)$ are identically and independently distributed (i.i.d.) with the uniform distribution in the interval $[0, 255]$.
   (Hint: Use MATLAB command 'rand')
   1.2) Random matrix, $t_2(x, y)$, where all elements of $t_2(x, y)$ are identically and independently distributed (i.i.d.) with the uniform distribution in the interval $[0, 255]$. $t_1(x, y) \neq t_2(x, y)$
   1.3) Noise corrupted image $f(x, y)$ using $f_0(x, y)$, $t_1(x, y)$, and $t_2(x, y)$ as

$$f(x,y) = \begin{cases} 255 & , \text{ if } f_0(x,y) > t_1(x,y), \\ 0 & , \text{ if } f_0(x,y) < t_2(x,y), \\ f_0(x,y) & , \text{ otherwise} \end{cases} \tag{1}$$

   1.4) Filtering $g(x, y) = f(x, y) * w(x, y)$, where $w(x, y)$ is
      1.4.1) 3×3 Gaussian filter with $\sigma = 1$;
      1.4.2) 3×3 Median filter;
      (Hint: use 'medfilt2')
      1.4.3) 3×3 Wiener filter;
      (Hint: use 'wiener2')
      1.4.4) Adaptive filter (see slide 10 of Lecture 13) resulting in :

$$g(x,y) = f(x,y) - \frac{5000}{\sigma^2_{f(x,y)}}(f(x,y) - m(x,y)),$$

      where

$$m(x,y) = \frac{1}{9}\sum_{i=-1}^{1}\sum_{j=-1}^{1} f(x+i, y+j)$$

$$\sigma^2_{f(x,y)} = \frac{1}{9}\sum_{i=-1}^{1}\sum_{j=-1}^{1} (f(x+i,y+j) - m(x,y))^2$$

      (Hint: First find matrices $m(x, y)$ and sigma-squared(x, y))
2) Include in your HW3 report:
   2.1) (5 points) Print-out of your code;
   2.2) (5 points) Figure 1 showing $f(x, y)$ and the caption
   2.3) (5 points) Figure 2 showing $g(x, y)$ as the result of Gaussian filtering and the caption
   2.4) (5 points) Figure 3 showing $g(x, y)$ as the result of Median filtering and the caption
   2.5) (5 points) Figure 4 showing $g(x, y)$ as the result of Wiener filtering and the caption
   2.6) (5 points) Figure 5 showing $g(x, y)$ as the result of Adaptive filtering and the caption
   2.7) Comment about which of the filters you find best performing.

(16 points) Problem 2

Write a MATLAB code for computing the DFT of an image: $F(u,v) = |F(u,v)|e^{j\Phi(u,v)} \leftrightarrow f(x,y)$. As input, use the image for Problem 2 that is available on the class website. Include in your HW5 report:

1) (5 points) Print-out of your code;
   (Hint: use 'double(rgb2gray(imread(·))', 'fft2', 'ifft2', 'fftshift', 'real')
2) (5 points) Figure 6 showing $f_1(x,y)$ which is the inverse DFT of $F_1(u,v) = \exp(j\Phi(u,v))$, i.e., $F_1(u,v)$ is obtained from $F(u,v)$ by setting the magnitude $|F(u,v)| = 1$, forall u, v.
3) (5 points) Figure 7 showing $f_2(x,y)$ which is the inverse DFT of $F_2(u,v) = |F(u,v)|$, i.e., $F_2(u,v)$ is obtained from $F(u,v)$ by setting the phase $\Phi(u,v) = 0$, forall u, v.
4) (1 point) Comment on the similarity and differences of $f_1(x,y)$ and $f_2(x,y)$ relative to the original image $f(x,y)$

(30 points) Problem 3

Design a Wiener filter to restore an original (unknown) image from the image provided on the class website. We only know that the image degradation comes from motion blur and additive Gaussian noise, but we do not know the amount of motion blur and the Gaussian variance. Use a trial-and-error strategy to identify the best Wiener filter.

1) (10 points) Write the expression and parameters of the best Wiener filter in the homework report.
2) (20 points) Show your best restoration result in Figure 8.

IMPORTANT:
In your report, all figures must have captions. Each missing caption will be penalized with 5 points.

(24 points) Problems from the Textbook:

- 4.17 (4 points)
- 4.23 (4 points)
- 4.26 (4 points)
- 4.28 (4 points)
- 4.29 (4 points)
- 4.33 (4 points)