ECE468/CS519: HOMEWORK 5
due 11/20/2015 by 3pm

(40 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

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

(1)

1.4) Filtering \( g(x, y) = f(x, y) * w(x, y) \), where \( w(x, y) \) is
   1.4.1) \( 3 \times 3 \) Gaussian filter with \( \sigma = 1; \)
   1.4.2) \( 3 \times 3 \) Median filter;
       (Hint: use ‘medfilt2’)
   1.4.3) 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 HW5 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) (10 points) Figure 3 showing \( g(x, y) \) as the result of Median filtering and the caption
   2.5) (15 points) Figure 4 showing \( g(x, y) \) as the result of Adaptive filtering and the caption
(20 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’, ‘ffshift’, ‘real’)
2) (5 points) Figure 5 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 6 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) (5 points) Comment on the similarity and differences of \( f_1(x, y) \) and \( f_2(x, y) \) relative to the original image \( f(x, y) \)

(10 points) Problem 3
Consider an image-degradation system with the impulse response
\[
h(x, y) = e^{-[x^2+y^2]}.
\]
Suppose that the input to the system is an image that shows a line of infinitesimal width, located at \( y = y_0 \), and modeled by
\[
f(x, y) = \delta(y - y_0),
\]
where \( \delta(\cdot) \) is the standard impulse function. Compute the output image \( g(x, y) = f(x, y) \star h(x, y) \).

(30 points) Problems from the Textbook
- 5.24 (10pts)
- 5.29 (10pts)
- 5.30 (10pts)

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