CS270 Digital Image processing
Homework 4
Due date: Nov 27^{th}, 2018
作业结果提交纸质版，课堂提交或送至信息学院 2 号楼 302G 办公室（请务必同时在名单上签名）
程序代码每题一个文件夹，请加入注释，最后压缩打包发送至助教刘宇婷邮箱：liuyt1@shanghaitech.edu.cn。请在邮件标题和压缩文件名中注明姓名、学号。

Note: There are two functions you may refer for better display.

(1) "ImageDisplay.m": to display the gray image properly.

(2) "scale2bytes.m": to extend the intensity level to [0,255].

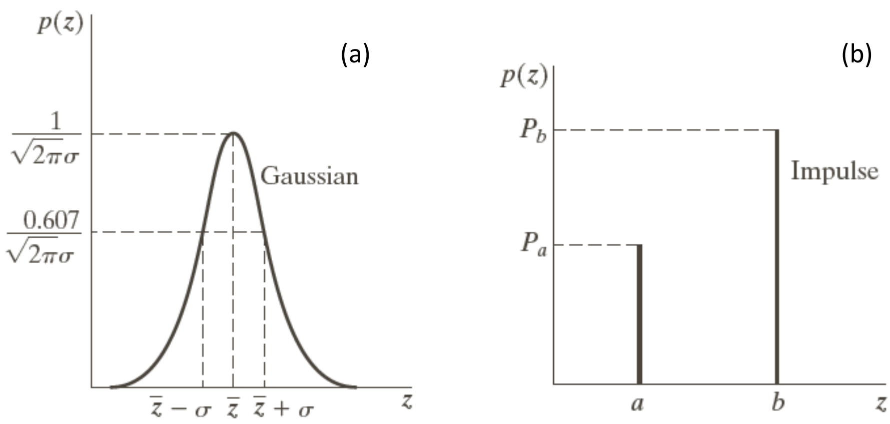
1. Noise Generators

This is a generic project, in the sense that the programs developed here are used in several of the problems that follow. See the figure for the shapes and parameters of the following noise probability density functions.

(a) Find (or develop) a program to add Gaussian noise to an image. You must be able to specify the noise mean and variance.

(b) Find (or develop) a program to add salt-and-pepper (impulse) noise to an image. You must be able to specify the probabilities of each of the two noise components.

Note: Your program must be capable of generating random numbers organized as a matrix of specified size (including a single random number). This problem is to generate a noise image from a histogram. You may use the function "imnoise" to check your result, but do not use it for the homework



1) Print out the functions that generate the noise image in (a) and (b).
2) Add the Gaussian noise to Image "Test1.mat", then display the image with noise and its histogram; (The mean and variance of the noise intensity are 50 and 25 respectively.)
3) Add the salt-and-pepper noise to Image "Test1.mat", then display the image with noise and its histogram; (a=0, b=255, and Pa=Pb=0.1)

2. Noise Reduction Using a Median Filter

Add salt-and-pepper noise with a=0, b=255, Pa= Pb = 0.2 to “Test2.mat”.

1) Display the image with salt-and-pepper noise in *subplot(2,2,1)*.
2) Apply 5*5 median filter to the image in 1) and display the result in *subplot(2,2,2)*.
3) Apply 5*5 median filter again to the image in 2) and display the result in subplot(2,2,3).
4) Apply max 5*5 adaptive median filter to the image in 1) and display the result in *subplot(2,2,4)*.
   Compare the results of 2), 3) and 4) and comment.

3. Periodic Noise Reduction Using a Notch Filter

Write a program that implements sinusoidal noise of the form given as following.

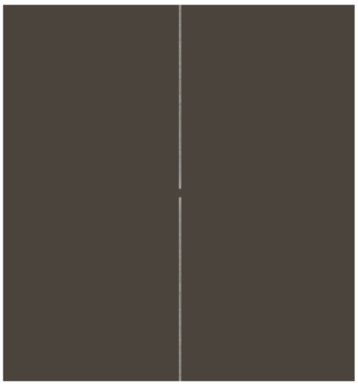
$$f(x, y) = A\cos(u_0 x + v_0 y)$$

and it is a pair of conjugate impulses in the frequency domain

$$F(u, v) = -\frac{A}{2}\left[\delta\left(u - \frac{u_0}{2\pi}, v - \frac{v_0}{2\pi}\right) + \delta\left(u + \frac{u_0}{2\pi}, v + \frac{v_0}{2\pi}\right)\right]$$

The inputs to the program must be the amplitude, A, and the two frequency components u_0 and v_0 shown in the equation.

(1) Add sinusoidal noise to “Test3.mat”, with $u_0 = N/2$ and $v_0 = 0$. The value of A must be high enough for the noise to be clearly visible in the image. N is the size of image matrix.
(2) Compute and display the spectrum of the image.
(3) Notch-filter the image using a notch filter of the form shown as below.



4. Parametric Wiener Filter

1) Implement a blurring filter as the following equation to blur "Test3.mat" in the +45-degree direction using T = 1, a=b=0.1.

$$H(u,v) = \frac{T}{\pi(ua+vb)}\sin[\pi(ua+vb)]e^{-j\pi(ua+vb)}$$

2) Add Gaussian noise of 0 mean and variance of 10 to the blurred image in 1).
3) Restore the image using the parametric Wiener filter given by

$$\mathrm{SNR} = \frac{\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}|F(u,v)|^2}{\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}|N(u,v)|^2}$$

Display the image from 1), 2) and 3) in *subplot(2,2,1)*, *subplot(2,2,2)*. *subplot(2,2,3)* respectively.