COMP/BMME 775, Fall 2016 Assigment 1: Hough Transform Pizer
Passed out: Tuesday, 4 September 2018, Due: Tuesday 25 September 2018. Please be aware that Prof. Pizer will not be available to answer questions on this assignment after 17 September.
Pass in this assignment on paper, not via email or any other electronic means.

In this assignment you will write a procedure to carry out the Hough transform for disks in 2D images and apply it to both computer generated test images and images of the real world.

1. Doing the Hough transform will require you to compute an image of gradients of the input image. On sakkai you will be provided a program, named **Derivarive.m**, to take the x and the y first spatial derivatives of a $2^m \times 2^m$ 2D image at scale σ using the derivative of Gaussian approach; the inputs to this program are σ and the image to be processed; and the outputs are two images the first one of which is derivative along the x direction, the second is a derivative along the y direction. You will need this program for other assignments.

2. Write a procedure that takes a $2^m \times 2^m$ 2D image in and the following parameters, including a disk radius, and produces the center positions (x,y) of disks with that radius in the image.

   Parameters
   - A disk radius in pixels
   - The intensity polarity of the desired disk (light on dark or dark on light)
   - The Parzen standard deviation, controlling the smoothing of the accumulator function.
   - A gradient magnitude threshold, controlling which pixels are boundary-like enough to vote.
   - The mean and standard deviation of a sigmoid function mapping gradient magnitude to vote strength. A sigmoid function is a cumulative Gaussian. There is a matlab function named **normcdf** for giving the value of this function given the input, which here is a gradient magnitude, given that mean and standard deviation.
   - The scale (Gaussian standard deviation) at which the intensity gradient is calculated.

   The method should produce a 2D accumulator (feature space) array indexed by (x,y) center values as well as a list of voting pixel locations together with the feature space positions they voted for. The method should deliver the accumulator position with the most votes and display, superimposed over the image data, the disk chosen. Also, upon a command from the user the method should remove the votes to the accumulator arrays from voters who voted the winning position, thus producing new accumulator array values from which the disk with the most votes will be selected.

   The method should produce votes by applying your gradient of a Gaussian procedure to the image, thresholding the magnitude of each resulting pixel, and if the threshold is passed, voting for centers along the gradient direction, according to the radius value and the sense of the gradient direction relative to the desired intensity polarity. After the votes are collected, the accumulator array should be smoothed by a Gaussian in the (x,y) directions according to the Parzen standard deviation, before the maximum is found. A function for convolving an image with a Gaussian named **imgaussfilt** can be found in matlab.

3. You should write a program that, given the discrete disk radius and a list of possible disk intensities and a number of disks in a specified image position range, generates test images with randomly positioned disks. Moreover, given blurring levels and intensity noise levels it will apply the blurring and produce random Gaussian distributed noise with the given intensity noise standard deviation. You are requested to apply your Hough disk program to a variety of images so generated and to report the effect of blurring, of noise level, and of disk overlap on the ability to extract the disks, as well as of

your choice of the input parameters to your Hough transform program. Your report should use good English and should be as scientifically valid as you can make it.

4. Locate on the web some images including disks. Apply your program to these after measuring by hand the disk sizes in those images. Comment on the success of your program and on the parameter values you used. Also, comment on the sensitivity of the selection to the value of the radius given, i.e., how close the actual radius needs to be to cause the disk to be selected.

What you should pass in, on paper

Some sample images and next to them the images with selected disks indicated by a superimposed circle. Your explanations of the behavior of your method; see items 3 and 4. I expect all of this on paper, not sent electronically.