ECE 172a	Machine Vision	#12	Pamela Cosman	2/10/12

HOMEWORK 4: Due Friday Feb 17 by start of class

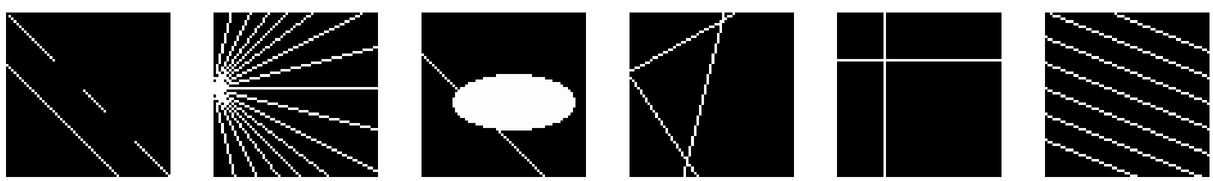
1. **Hough transforms**

For this problem you will use the Matlab built-in function `hough()` which performs a Hough transform of a binary image. Functions `plotSHT(), plotPeaks(), and plotLines()` are provided to visualize the Hough transfrom result. The input image for the Hough transform is expected to be a binary edge map. The format of the function call is

```
[H,T,R] = hough(BW,'RhoResolution',rhoResol,'Theta',thetaResol);
plotSHT(H,T,R);
```

where BW is the binary edge map, and we will set the bin size `rhoResol = 0.5` and `thetaResol = -90:0.5:89.5`.

(a) Make at least 5 binary test images and run the Hough algorithm on them. You can make test images which have lines (individual lines, or many lines with the same slope, or many lines with the same intercept, etc.) or blobs, or circles. Here are some examples of test images:



In each case, look at the Hough output array using the plotSHT command, and *interpret it*. That is, what portions of the array correspond to what features in your image? Include in your homework printouts of your test images, and of the corresponding Hough arrays. You can try making the Hough array size mentioned at the beginning; you can also try other sizes if you want.

(b) Consider a real world application of the Hough transform. You scan a piece of paper with your phone, but the picture you taken is rotated. The goal is to find the angle of rotation using the Hough transform, to rectify the image. Read in a color image, and perform color to graylevel conversion with *double* data type as follows:

```
I = imread('bookcover.tif');
I_gray = rgb2gray(I);
I_gray = double(I_gray);
```

Find the binary edge image BW by using some edge detector. Perform the Hough transform and find the bins that accumulated the most points in the Hough array:

```
[H,T,R] = hough(BW,'RhoResolution',rhoResol,'Theta',thetaResol);
P  = houghpeaks(H,peakNumber);
plotPeak(H,T,R,P);
```

Set *peakNumber* to 4 in order to find 4 peaks. You can subsequently find and draw lines on the original image by using

```
lines = houghlines(BW,T,R,P,'FillGap',5,'MinLength',minLength);
plotLines( I, lines )
```

To find the edges of the book cover, you need to set a proper minimum line length to filter out small segments. The theta and rho of the lines are stored in `lines` struct. Use angle information in `lines` struct with function `imrotate(I, angle)` to rectify the input image. Turn in figures of the Hough array with peaks and lines you find on the original image, and the angle you used for rectification.

2. **Chromaticity diagrams**

On the web site you will find a text file called `cie` which contains color matching functions in the XYZ coordinate system. The format of the file is `wavelength X Y Z` from 380 nanometers to 780 nanometers. To read it in, type: load cie -ascii

(a) For this problem we ask you to produce hardcopy of your plots as well as of your matlab commands. On one graph, plot the color matching functions, $X(\lambda)$, $Y(\lambda)$, $Z(\lambda)$. On another graph, plot the xy chromaticity diagram. Connect the "line of purples" on your diagram.

(b) The conversion from the CIE XYZ space to the NTSC receiver primary system R_N, G_N, B_N is given by the following linear transformation:

$$\begin{bmatrix} R_N \\ G_N \\ B_N \end{bmatrix} = \begin{bmatrix} 1.910 & -0.533 & -0.288 \\ -0.985 & 2.000 & -0.028 \\ 0.058 & -0.118 & 0.896 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

The Society of Motion Picture and Television Engineers (SMPTE) made its own receiver primary color coordinate system. The conversion from the CIE XYZ space to the SMPTE receiver primary system R_S, G_S, B_S is given by the following linear transformation:

$$\begin{bmatrix} R_S \\ G_S \\ B_S \end{bmatrix} = \begin{bmatrix} 3.508 & -1.741 & -0.544 \\ -1.069 & 1.977 & 0.035 \\ 0.056 & -0.197 & 1.051 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

Suppose there existed two sets of phosphors which exactly corresponded to the NTSC and SMPTE primaries. Inside the xy chromaticity diagram, plot the two triangles that correspond to the color gamuts of these two sets of phosphors. Does it appear that the NTSC or SMPTE primaries provide a larger gamut?

3. **Color images: Change of reference white**

This is a pencil-and-paper problem, no Matlab. We are given tristimulus values T_1, T_2, and T_3 for a color C. The tristimulus values are relative to a reference white W_1. In other words, for our color, the tristimulus values are given by

$$T_1(C) = \frac{A_1(C)}{A_1(W_1)}$$

$$T_2(C) = \frac{A_2(C)}{A_2(W_1)}$$

$$T_3(C) = \frac{A_3(C)}{A_3(W_1)}$$

You may interpret the A's as power knob settings in the color matching experiment. What would the new tristimulus values $\hat{T}_1$, $\hat{T}_2$, and $\hat{T}_3$ be for our color in a coordinate system that uses the same primaries but a reference white W_2? Derive your expression in terms of tristimulus values in the original coordinate system. (So your expression for the $\hat{T}$'s should involve only T's, no A's.)