ECE178 HW #3

DUE: Friday, October 16, 2009 (by 5PM in the HW box)
Please write down all the steps involved for complete credit

Q1. Review textbook problems 3.3, 3.5, 3.6. No need to turn in solutions to these problems.

Q2. Textbook Gonzalez and Woods (3rd Edition) problem 3.4

Q3. Textbook Gonzalez and Woods (3rd Edition) problem 3.11

Q4. Compute $y[n] = x[n] * x[n]$ where $x[n] = \begin{bmatrix} 1 & -1 & \boxed{7} & -1 & 1 \end{bmatrix}$, and * indicates linear discrete convolution. The boxed value represents the origin.

Q5. Compute $y[m,n] = x[m,n]*u[m,n]$ where $u[m,n]$ is a unit step function and $x[m,n]$ is defined as follows:

$$x[m,n] = \begin{bmatrix} 0 & 1 & 0 \\ 1 & \boxed{2} & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Q6. Compute $y[m,n] = x[m,n] * h[m,n]$ where $x[m,n]$ and $h[m,n]$ are defined as follows:

$$x[m,n] = \begin{bmatrix} \boxed{2} & -1 \\ -2 & 1 \end{bmatrix}, \quad h[m,n] = \begin{bmatrix} \boxed{-1} & 3 & -2 \\ 1 & 0 & 1 \\ 0 & 1 & -2 \end{bmatrix}$$

Q7. This MATLAB assignment is to implement the function discussed in lecture on Oct. 5th. We shall study the effect of histogram equalization and how it can be implemented with a **piecewise linear transformation** of the pixel values.

The original image is "lena.gif". Plot its histogram using the "imhist" command in MATLAB. Then, consider the darkened version of the image, called "darklena.gif". Again, plot its histogram using the "imhist" function and comment on the histogram difference between the two images. For the two gif images, see class website `www.ece.ucsb.edu/~manj/ece178`.

Then, use the histogram equalization command in MATLAB, called "histeq", on the "darklena.gif" image. Comment on the image quality obtained after the histogram equalization and comment on its histogram, with respect to the histograms obtained from "lena.gif" and "darklena.gif".

Now, we shall study the effect of using an appropriate piecewise linear transformation to the pixel values. The logic is as follows: say, we provide 2 vectors $\mathbf{a} = [a_1, a_2, a_3, a_4]$ and $\mathbf{b} = [b_1, b_2, b_3, b_4]$ as input. Then, as showed in Fig. 1, the region $[a_1 - a_2]$ is mapped to $[b_1 - b_2]$, the region $[a_2 - a_3]$ is mapped to $[b_2 - b_3]$ and the region $[a_3 - a_4]$ gets mapped to $[b_3 - b_4]$.

You have to choose a proper set of values for $\mathbf{a} = [a_1, a_2, a_3, a_4]$ and $\mathbf{b} = [b_1, b_2, b_3, b_4]$ and then use them to perform piecewise linear transformation of the pixel values. Your MATLAB
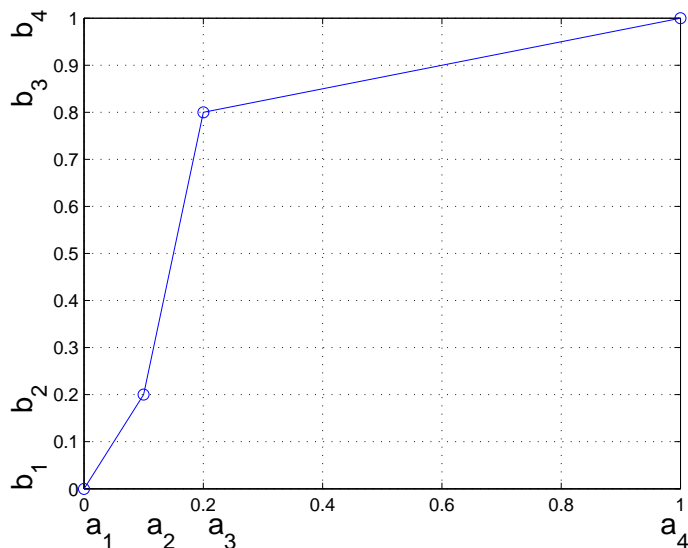
Figure 1: A piecewise linear stretching function using $\mathbf{a} = [a_1, a_2, a_3, a_4] = [0, 0.1, 0.2, 1.0]$ and $\mathbf{b} = [b_1, b_2, b_3, b_4] = [0, 0.2, 0.8, 1.0]$.

routine should take the "darklena.gif" image and $\mathbf{a}$ and $\mathbf{b}$ as inputs, and the output should be the image, with piecewise linear transformation performed. Using Fig. 1 as the reference, you shall use vectors $\mathbf{a}$ and $\mathbf{b}$, **each of length 4**, and set $a_1 = 0$, $a_4=1$, $b_1 = 0$ and $b_4 = 1$. Then, you should **intelligently** choose a_2, a_3, b_2 and b_3, so that the perceptual quality of the image obtained after piecewise linear transformation is good.

The pseudocode is as follows:

- $im =$ input image matrix
- use "find" function in MATLAB to find the pixel values in the image between a_i and a_{i+1}, for all i.
- The line between the coordinates (a_i, b_i) and (a_{i+1}, b_{i+1}) has the equation:

$$y = \frac{b_{i+1} - b_i}{a_{i+1} - a_i}(x - a_i) + b_i$$

  To implement the above mentioned logic in MATLAB, use
  $pix = \text{find}(im >= a(i) \ \& \ im < a(i+1));$
  $out(pix) = (im(pix) - a(i)) * (b(i+1) - b(i))/(a(i+1) - a(i)) + b(i)$
  where im is the input image and out is the output image.
- Repeat the above process for all i and thus, im will be converted to out.

Things to turn in (suggested to use the Publish-To option under File in the M-file editor):

(a) M-file
(b) Images obtained after using "histeq" and after using piecewise linear transformation
(c) Also plot their histograms alongwith the histograms of "lena.gif" and "darklena.gif".
(d) Comments on the differences between the histograms and also justify how you chose $\mathbf{a}$ and $\mathbf{b}$ for the piecewise linear transformation problem.

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