ECE547 Topics in Image Processing Tuesday Sep 01, 2009

Machine Problem 1

Lecturer: Prof. Minh Do *Due: Thursday Sept 10, 2009*

0 Preparation

1. In this machine problem, you are asked to write a MATLAB program to perform some processing tasks for the given test images. These images can be downloaded from

   `http://www.ifp.illinois.edu/~vuongle2/ECE547/ece547_mp1_imageset.zip`

2. You may want to consider the following MATLAB functions: `imread`, `imwrite`, `hist`, `histeq`, `conv2`, `fft2`, `ifft2`, `fftshift`, `abs`, and `angle`. MathWorks Inc. provides an excellent documentation on how to use MATLAB. You may learn more about MATLAB from their website at:

   `http://www.mathworks.com/access/helpdesk/help/techdoc/matlab.shtml`

   There is also a good list of online Matlab tutorials and Matlab books at:

   `http://www.duke.edu/~hpgavin/matlab.html`

1 Histogram Equalization

1. Write a function for computing the histogram of an image.
2. Implement the histogram equalization technique using inverse transformation of cumulative distribution function of gray level random variable.
3. Apply your histogram equalization functions on image Fig-mp1-1.tif.

2 Color Image Enhancement by Histogram Processing

1. Apply your histogram-equalization program made in problem 1 to the R, G, and B channel of the image Fig-mp1-2.tif separately.
2. Form an average histogram from the three histograms in part 1 and use it as the basis to obtain a single histogram equalization intensity transformation function. Apply this function to the R, G, and B components individually.

3 Lowpass Filtering

1. Implement the Gaussian lowpass filter with frequency response $H(u,v) = e^{-D^2(u,v)/2D_0^2}$ where D_0 is the cutoff frequency. You must be able to specify the size, $M \times N$, of the resulting 2D function and the location of the center of the Gaussian function.
2. Use the filter made in part 1 to lowpass filter the image Fig-mp1-3.tif.

4 Fourier analysis and filtering

4.1 FFT Analysis

For the following tasks, please run them on the two images lena.png and beckman.jpg in the given image set. When saving your output, replace `xxx` with `lena` and `beckman` as appropriate. For example, the output of task 1 with `beckman.jpg` should be `beckman1-mag.png` and `beckman1-ang.jpg`[1].

1. Compute the DFT $F(x; y)$ and display the magnitude and phase of $F(x; y)$. Save the magnitude as `xxx1-mag.png` and the phase as `xxx1-ang.png`.

2. Keep the magnitude of $F(x; y)$ and set the phase to 0 for each frequency sample. Take the inverse DFT and compare the results to the original images. Save the result as `xxx2.png`.

3. Keep the phase of $F(x; y)$ and set the magnitude to unity for each frequency sample. Take the inverse DFT and compare the results to the original image. Save the result as `xxx3.png`.

4. Keep the phase of $F(x; y)$ and replace the magnitude of each frequency sample by its square root. Take the inverse DFT and compare the results to the original image. You should observe an edge enhancement. Save the result as `xxx4.png`.

5. Low-pass filter the test images. First use the rectangular low pass filter

$$H(x; y) = \begin{cases} 1 & |x| < C_x \text{ and } |y| < C_y, \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

   where C_x and C_y are the normalized cut-off frequencies for x and y respectively. The normalization is such that the "whole image" ranges from -1 to 1.

   Start with $C_x = C_y = 0.3$. Save the result as `xxx5a.png`. Then try another low-pass filter and save that result as `xxx5b.png`. You may try a different C_x and C_y or use another filter entirely.

4.2 Bonus: Image Cleanup (Lena's Jailbreak)

Use frequency domain methods (**Hint**: use a band-pass filter) to remove the black bars in `lena-bar.png` in the image set. Save the result as `lena-bar-clean.png`.

[1]Since the source for the Beckman image was a jpeg, we kept the format. However, we usually save image processing results as png or other lossless formats to preserve fidelity.

5 Hand-in

Please create an archive of your work named `netid.zip` or `netid.tar.gz`, where `netid` is your NetID. In this archive, include:

1. Source code for performing the tasks above. If you performed the task on the command line, consider using the command history or the `diary` function.
2. All of the images and plots created by your programs.
3. A short report (plain text will be fine, doc or pdf will be accepted) which includes:
   (a) Your name.
   (b) For problem 1: your explanation why the resulting image was enhanced as it was.
   (c) For problem 2: your comparison and explanation the differences in the images in part 1 and part 2.
   (d) For problem 3: your comment about the result.
   (e) For problem 4: your observations on the results of tasks 2–4; your choice of a low-pass filter for task 5 and a comparison between the two low-pass filter results; a brief description of how you cleaned up `lena-bar.png` in the bonus section if you have done it.

Email a copy of the archive to both TAs: `vuongle2@ifp.uiuc.edu` and `jyang29@illinois.edu`