SD 575 Image Processing

Fall 2016

Lab 1: Fundamentals of Image Processing
Due Friday September 30 2016 at 11:59 PM (Midnight)

Note: All lab reports will be submitted as soft copies to your group dropbox on LEARN.

For help on how to use the Matlab functions mentioned throughout the lab, please type `help` followed by the function (e.g., `help imread`).

1   Overview

The goal of this lab is to provide some hands-on experience with fundamental image processing concepts and techniques. A common source of test images for image processing techniques can be obtained from the USC-SIPI image database. Many of these stock images are commonly used by researchers as a test-bed to test new image processing algorithms.

http://sipi.usc.edu/database/

For this lab, we will study some fundamental image enhancement techniques such as digital zooming, spatial filtering, and point operations for image enhancement.

The following images will be used for testing purposes (they can be downloaded from LEARN):

- lena.tif

- tire.tif

- cameraman.tif

These images can be loaded using the `imread` function.

2   Image Quality Measures

One of the underlying goals of image enhancement is to produce an image that is more visually pleasing than the original. However, this can be very subjective, making it difficult to say whether one method

provides better quality than another. To quantitatively study the effects of image enhancement algorithms on image quality, it is necessary to establish empirical measures for image quality. This allows different image enhancement algorithms to be compared systematically using the same set of test images to identify whether a particular algorithm produces better results. A commonly used metric for image quality assessment is Peak Signal to Noise Ratio (PSNR), which originated from signal theory.

$$
\begin{aligned}
PSNR &= 10 \log_{10} \left(\frac{MAX_f^2}{MSE} \right) \\
MSE &= \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \| f(i,j) - g(i,j) \|^2
\end{aligned}
\tag{1}
$$

Create a new function `PSNR` that, given a reference image `f` and a test image `g` as inputs, outputs the PSNR value `PSNR_out`.

Hint: Avoid doing loops. The `sum` function will come in handy here.

3 Digital Zooming

Let us first study the effect of different digital zooming techniques on the image quality of the resulting up-sampled image. For this study, we will use the Lena and Cameraman images. Load the Lena and Cameraman images and convert them to grayscale images using the `rgb2gray` function. First, reduce the resolution of the images by a factor of 4 in both the horizontal and vertical direction using bilinear interpolation. Plot the down-sampled images. Now, perform digital zooming to increase the resolution of the down-sampled image back to the resolution of the original images using each of the following methods:

- nearest neighbor interpolation

- bilinear interpolation

- bicubic interpolation

Plot the up-sampled images. Also, compute the PSNR between the original images and each of the corresponding up-sampled images.

1. What can you observed about the up-sampled images produced by each of the methods?

2. How do the different methods compare to each other in terms of PSNR as well as visual quality? Why?

3. What parts of the image seems to work well using these digital zooming methods? What parts of the image doesn't? Why?

4. Compare the zooming results between Lena and Cameraman. Which image results in higher PSNR? Which image looks better when restored to the original resolution using digital zooming methods? Why?

5. What does the PSNR tell you about each of the methods? Does it reflect what is observed visually?

Hint: The `figure`, `imshow`, and `imresize` functions will be useful here.

4 Discrete Convolution for Image Processing

Let us study how convolution can be used for the purpose of image processing. For this study, we will use the Lena image. Load the Lena image and convert it to a grayscale image using the `rgb2gray` function. Furthermore, to get intensity of the image within the range of 0 to 1, use the `double` function on the image and then divide it by 255. We will now construct three impulse functions `h1`, `h2`, `h3` as follows:

$$h1 = (1/6)*ones(1,6);$$
$$h2 = h1';$$
$$h3 = [-1\ 1];$$

Now use the `conv2` function to convolve the Lena image with the impulse functions `h1`, `h2`, and `h3` separately. Plot the original image as well as the convolved images.

1. What did convolving the image with `h1` do to the image? Looking at the impulse function, explain why convolving the image with `h1` yields such results.

2. What did convolving the image with `h2` do to the image? Looking at the impulse function, explain why convolving the image with `h2` yields such results.

3. What did convolving the image with `h3` do to the image? Looking at the impulse function, explain why convolving the image with `h3` yields such results.

4. Based on these results, what role can convolution perform in the context of image processing?

5 Point Operations for Image Enhancement

Let us study how point operations can be used to enhance the contrast of an image. For this study, we will use the tire image. Plot the image as well as the histogram of the image using the `imhist` function.

1. Explain what the histogram of an image represents. Why is it useful?

2. Describe how the histogram looks like in the context of intensity distribution. What does the histogram say about the image?

Now, let us apply the image negative transform on the image. Plot the image as well as the histogram of the image using the `imhist` function.

1. Describe how the histogram looks like in the context of intensity distribution. How does it differ from the histogram of the original image? Why?

Now, let us apply two power-law transformations on the tire image, one with an exponent term γ of 0.5 and one with an exponent term γ of 1.3. Recall that the power-law transformation is

$$I_{out} = I_{in}^{\gamma} \tag{2}$$

Plot the two transformed images and the associated histograms.

1. Describe the appearance of the transformed images. Why do they appear this way?

2. Describe how each of the histogram looks like in the context of intensity distribution. Why do they look like this? What does each histogram say about each transformed image?

3. Compared with the original image, which of the transforms should you use to enhance the image? Why?

Finally, let us perform histogram equalization on the tire image using the `histeq` function. Plot the equalized image and the associated histogram.

1. Describe the appearance of the equalized image.

2. Describe how the histogram looks like in the context of intensity distribution. Why does it look like this? What does each histogram say about each equalized image?

6 Report

Include in your report:

- A brief introduction.

- Pertinent graphs and images (properly labelled).

- Include code (can be included in appendix).

- Include responses to all questions.

- A brief summary of your results with conclusions.