Digital Image Processing Laboratory: 2-D Random Processes

December 21, 1998

Introduction

This laboratory explores the use of 2-D random process models for images. You may implement you programs in Matlab. Make sure that all plots have accurate and clearly labeled axeses, and have titles that indicate what is being plotted.

1 Power Spectral Density of an Image

In this problem, you will use Matlab to read and analyze the gray scale image *img04g.tif*. If you are unfamiliar with Matlab, please refer to the Matlab tutorial information listed on the main web page for this laboratory.

1. Download the Matlab m-file *SpecAnal.m.* and the gray scale image *img04g.tif*. The m-file estimates the power spectral density by computing the logarithm of the normalized energy spectrum over a 64×64 window of the image. The comment lines in *SpecAnal.m* explain how the m-file operates.

2. Run *SpecAnal.m*. The m-file will display the image img04g.tiff and show a meshplot of the estimated log power spectral density. Print out the two figures.

3. Run *SpecAnal.m* for 128×128 and 256×256 block sizes. Print out the log power spectral density mesh plots for each case. Notice the spectral plots remain noisy even when the block size is increased.

4. Write a Matlab function, *BetterSpecAnal(x)*, which computes a better estimate of the power spectral density of the 2-D array `x`. Your new m-file should:

   - Use 25 nonoverlapping image windows of size 64×64. These windows should be selected from the center of `x`.
   - Apply a 2-D separable Hamming window to each 64×64 window.
   - Compute the squared magnitude of the energy spectrum for each window.
   - Average the power spectral density of the 25 windows.
   - Display a mesh plot of the log of the estimated power spectral density.

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5. Use *BetterSpecAnal(x)* to compute the power spectral density of img04g.tif, and print out your result as a mesh plot of the log power spectral density.

Section 1 Report:
Hand in:

1. Print out of the gray scale image *img04g.tif*.
2. The power spectral density plots for block sizes of 64×64, 128×128, and 256×256.
3. The improved power spectral density estimate.
4. Your *BetterSpecAnal.m* m-file.

2 Power Spectral Density of a 2-D AR Process

In this problem, you will generate a synthetic 2-D AR process using Matlab, and you will analyze its power spectral density. In the steps below, you will be asked to display images, `x`, in the 8-bit range of 0 to 255. To do this in Matlab set a colormap of the form

```
graymap = [0:255; 0:255; 0:255]'/255;
colormap(graymap);
```

and then use the command `image(x+1)` to display `x`. To insure that the image's aspect ratio is correct, you may also use the command `axis('image')`.

1. Use the Matlab functions *rand* to generate x, a 512×512 image with independent random numbers each uniformly distributed on the interval $[-0.5, 0.5]$. Display the image $255 * (x + 0.5)$ using matlab.
2. Filter the image x to produce the image y using an IIR filter with transfer function
$$H(z_1, z_2) = \frac{3}{1 - 0.99z_1^{-1} - 0.99z_2^{-1} + 0.9801z_1^{-1}z_2^{-1}} .$$
3. Display the image $y + 127$ using matlab and print out the result.
4. Theoretically calculate $S_y(e^{j\mu}, e^{j\nu})$ the power spectral density of y, plot the magnitude of S_y using *mesh* and print out your result.
5. Use *BetterSpecAnal(y)*, your Matlab function from the previous exercise, to estimate the power spectral density of y. Plot the estimated power spectral density and print out the result.

Section 2 Report:

Hand in:

1. A print out of the image $255 * (x + 0.5)$.
2. A print out of the image $y + 127$.
3. A mesh plot of the function $\log S_y(e^{j\mu}, e^{j\nu})$.
4. A mesh plot of the log of the estimated power spectral density of y using *BetterSpecAnal(y)*.