EE6310 Image and Video Processing, Spring 2024

Indian Institute of Technology Hyderabad
Homework 3, Assigned 25.02.2024, Due **11:59 pm on 04.03.2024.**

1 Periodic Convolution

1. Write a program to circularly convolve two images. Test your program by using an image and an averaging filter of size 5×5. Verify that the IDFT of the product of the image and filter DFT does indeed result in circular convolution. (5)

2. Linearly convolve the same image and filter using the circular convolution function above after appropriate zero padding. (3)

3. Experiment with different filter kernel sizes and present your observation on when direct linear convolution is faster than the IDFT-DFT approach using zero padding. (2)

2 Linear Image Filters

We discussed various linear image filters in class. In this problem you will experiment with the various design parameters to develop intuition on how to select them.

1. What is the filter parameter of the averaging filter? Experiment with different parameters and plot the DFT magnitude spectrum at each parameter setting. Verify that this is indeed a low pass filter. What can you infer from the filter spectrum in relation to the parameter values? (1)

2. What are the filter parameters of the Gaussian filter? Experiment with different parameters and plot the DFT magnitude spectrum at each parameter setting. Verify that this is indeed a low pass filter. What can you infer from the filter spectrum in relation to the parameter values? (1)

3. Generate a band pass filter by taking the difference of two Gaussian filters. Verify from the DFT magnitude spectrum that this is indeed a band pass filter. What are the parameters of this filter? Experiment with various parameters values of the individual Gaussians. What can you infer from the filter spectrum in relation to the parameter values? (2)

4. Plot the DFT magnitude spectrum of a Laplacian filter. Verify that this is a high pass filter. (1)

3 Applications of Linear Filters

1. In this problem you will denoise images using the linear filtering techniques discussed in class. Like the last assignment, use additive white Gaussian noise (AWGN) with zero mean and variance $\sigma^2 = 25$. Write a program to denoise the image using the following techniques:

   (a) Average filter of size $M \times M$. Vary M from 3 to 15 in increments of 2 and observe the tradeoff between denoising and smoothing. What is an optimal window size for this noise level? (1)

   (b) Gaussian filter of size 5×5. Experiment with the standard deviation σ_h of the filter from 0.5 to 5 in steps of 0.5 and observe its effect on denoising. What happens when you keep the standard deviation of the filter constant but vary the kernel size? (1)

2. In this problem you will explore how edge detection and enhancement can be achieved using linear band pass and high pass filters. Work with the `mandrill` image (from the USC dataset) in this question. Apply each of the band pass and high pass filters you designed in Question 2 to this image and observe the output. Tabulate your observations for each filter parameter choice. (3)