Shiraz University

# Digital Image Processing (April 2023)

# Homework #2

# Due Date: 1402/02/14

## Applying spatial filters & Discrete Fourier Transform:

### 1. Introduction to DFT:

*Input images: all the images in test_images folder*

In this problem, we're going to work with a great and powerful tool in the image processing area called *Fourier Transform*. The Fourier transform represents any function that can be expressed as the integral of sines and cosines multiplied by the weighted function. Also, any function represented in either Fourier series or transform can be reconstructed completely by an inverse process. This is known as the inverse Fourier transform. Apply Fourier Transform on test images in the zip file and ***plot*** and ***explain*** the results.

### 2. Spectrum and Phase Angle

*Input images: lenna.tif, cameraman.bmp*

The Fourier transform is complex, so it can be expressed in polar form as

$$f(u,v) = |F(u,v)|e^{j\varphi(u,v)}$$

where $|F(u,v)|$ is the spectrum and

$$|F(u,v)| = \left[R_{(u,v)}^2 + I_{(u,v)}^2\right]^{\frac{1}{2}}$$

also $\varphi(u,v)$ is the phase angle and

$$\varphi(u,v) = \tan^{-1}\left[\frac{I_{(u,v)}}{R_{(u,v)}}\right]$$

a) Compute and plot the spectrum and phase angle for *lenna.tif*
b) Compute and plot the inverse transform using only the phase term
c) Compute and plot the inverse transform using the spectrum term
d) Compute the spectrum of *cameraman.bmp* and calculate the inverse transform using spectrum of *cameraman.bmp* and phase angle of *lenna.tif*

## 3. Spatial Filtering:

a. Spatial Domain Filters:

*Input images: cameraman.bmp*

In this part, we're going to work with some spatial domain filters in order to denoise some additive noises. For this purpose, first, you should add these listed noises to the image, and then, among the spatial filters listed below find the one that is best suited for your purpose.

Noises:

1. Salt & pepper with 1%, 4%
2. Gaussian noise with $\sigma = 1, 5$

Filters:

1. Arithmetic mean filter with 3*3 and 5*5
2. Median filter with 3*3 and 5*5

Compare and report your results of applying these filters with SSIM and PSNR criteria.

b. Frequency domain filters:

*Input images: lenna.tif, land.png*

The process of converting an image from the spatial domain to the frequency domain provides valuable insight into the nature of the image. In some cases, an operation can be performed more efficiently in the frequency domain than in the spatial domain.

I. In this section, follow these steps:

a. read the *lena.jpg*.
b. convert the images to grayscale.
c. Design and apply an ideal low-pass filter with a radius of 30.
d. Design and apply a Gaussian low-pass filter with a radius of 30.
e. Design and apply an ideal high-pass filter with a radius of 30.

After completing these subsections and reporting your results answer the following questions:

1. What are the uses of each of the above filters?
2. What is the significant difference between the results of ideal and Gaussian lowpass filters? And why this happened?

II. Read the image *land.png* and then, design a suitable filter for this image to denoise the image. Report the noisy and noiseless image and explain how your filter work.

c. Introduce a way to find a type of noise of the given image and apply this method to the noisy images that you made in section a.

ILPF:

$$f(u,v) = \begin{cases} 1, & if\ d(u,v) \leq r \\ 0, & else \end{cases}$$

GLPF:

$$f(u,v) = e^{-\frac{d^2(u,v)}{2d0}}$$

IHPF:

$$f(u,v) = \begin{cases} 0, & if\ d(u,v) \leq r \\ 1, & else \end{cases}$$

Where *d(u, v)* is the Euclidean distance of each pixel in the image from the center.