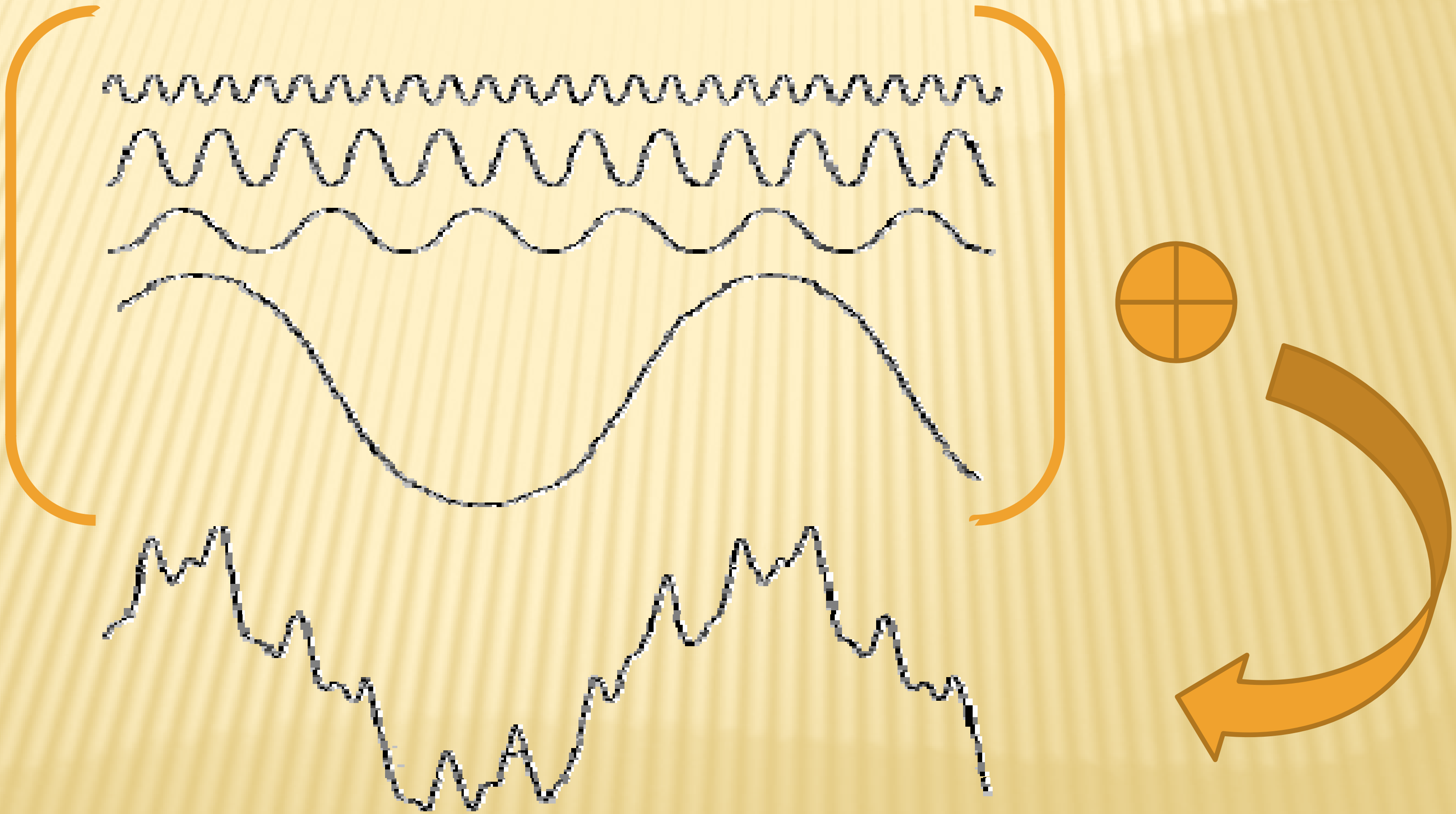
Lab Manual 09 G1

IMAGE ENHANCEMENT USING FREQUENCY DOMAIN

Digital Image Processing Fall 2010
muhammad.jamil@uettaxila.edu.pk

FOURIER TRANSFORM



1D DISCRETE FOURIER TRANSFORM

$$F(u) = \frac{1}{M}\sum_{x=0}^{M-1} f(x)e^{-j2\pi xu/M} \qquad for \quad u = 0,1,2,3,4,\ldots\ldots$$

$$e^{j\theta} = \cos\theta + j\sin\theta$$

$$F(u) = \frac{1}{M}\sum_{x=0}^{M-1} f(x)\left[\cos(2\pi ux/M) - j\sin(2\pi ux/M)\right]$$

EXAMPLE

$$f(x) = [2 \quad 3 \quad 7 \quad 4]$$

Apply DFT $F(u) = \frac{1}{M}\sum_{x=0}^{M-1} f(x)e^{-j2\pi xu/M}$ *for* $u = 0,1,2,3,4,.......$

We get

$$F(0) = \frac{1}{4}\left(f(x)e^{-j2\pi(0)(0)/4} + f(x)e^{-j2\pi(0)(1)/4} + f(x)e^{-j2\pi(0)(2)/4} + f(x)e^{-j2\pi(0)(3)/4}\right)$$

$$F(0) = 4.0000$$

EXAMPLE CONTINUE

$$F(1)=\frac{1}{4}\left(f(x)e^{-j2\pi(1)(0)/4}+f(x)e^{-j2\pi(1)(1)/4}+f(x)e^{-j2\pi(1)(2)/4}+f(x)e^{-j2\pi(1)(3)/4}\right)$$

$$F(1)=-1.2500-0.2500i$$

$$F(2)=\frac{1}{4}\left(f(x)e^{-j2\pi(2)(0)/4}+f(x)e^{-j2\pi(2)(1)/4}+f(x)e^{-j2\pi(2)(2)/4}+f(x)e^{-j2\pi(2)(3)/4}\right)$$

$$F(2)=0.5000$$

$$F(3)=\frac{1}{4}\left(f(x)e^{-j2\pi(3)(0)/4}+f(x)e^{-j2\pi(3)(1)/4}+f(x)e^{-j2\pi(3)(2)/4}+f(x)e^{-j2\pi(3)(3)/4}\right)$$

$$F(3)=-1.2500+0.2500i$$

EXAMPLE CONTINUE

$$F(u) = [4.0000 \quad -1.2500 - 0.2500i \quad 0.5000 + 0.0000i \quad -1.2500 + 0.2500i]$$

Real Part $R(u) = [4.0000 \quad -1.2500 \quad 0.5000 \quad -1.2500]$

Imaginary Part $I(u) = [0.0000 \quad -0.2500 \quad 0.0000 \quad 0.2500]$

FOURIER SPECTRUM

$$F(u) = |F(u)| e^{-j\varphi(u)}$$

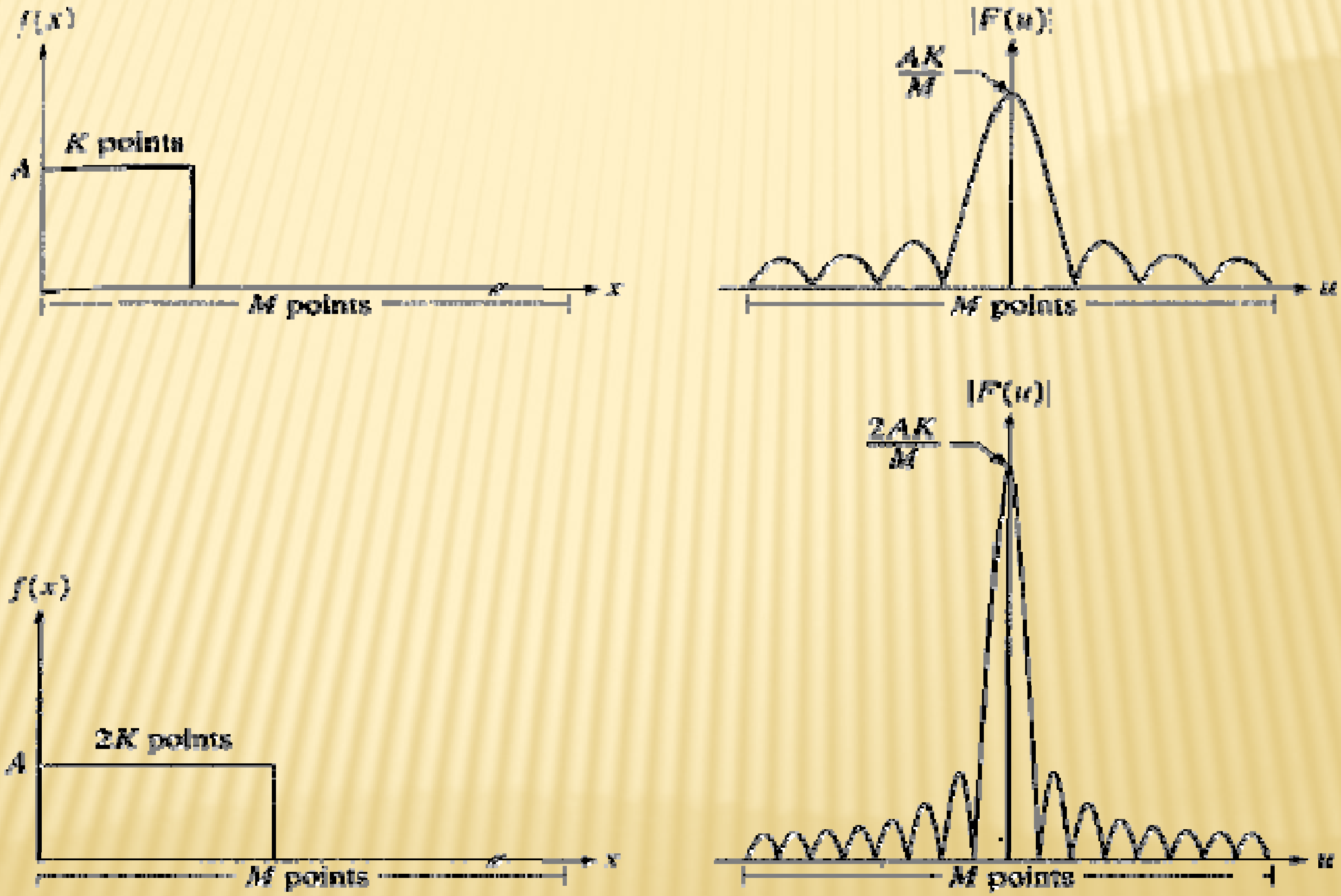
Magnitude Spectrum of Fourier Transform

$$|F(u)| = \sqrt{(R(u))^2 + (I(u))^2}$$

Phase Spectrum of Fourier Transform

$$\phi(u) = \tan^{-1}\left[\frac{I(u)}{R(u)}\right]$$

EXAMPLE 2


f(x)
K points
A
M points
x
|F(u)|
AK/M
M points
u
f(x)
2K points
A
M points
x
|F(u)|
2AK/M
M points
u

2D DFT

$$F(u,v)=\frac{1}{M}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-j2\pi(xu/M+vy/M)}$$

$$for \quad u=0,1,2,3,4,.......,M-1$$
$$for \quad v=0,1,2,3,4,.......,N-1$$

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

Magnitude Spectrum of Fourier Transform

$$|F(u,v)|=\sqrt{(R(u,v))^2+(I(u,v))^2}$$

Phase Spectrum of Fourier Transform

$$\phi(u,v)=\tan^{-1}\left[\frac{I(u,v)}{R(u,v)}\right]$$

2D INVERSE DFT

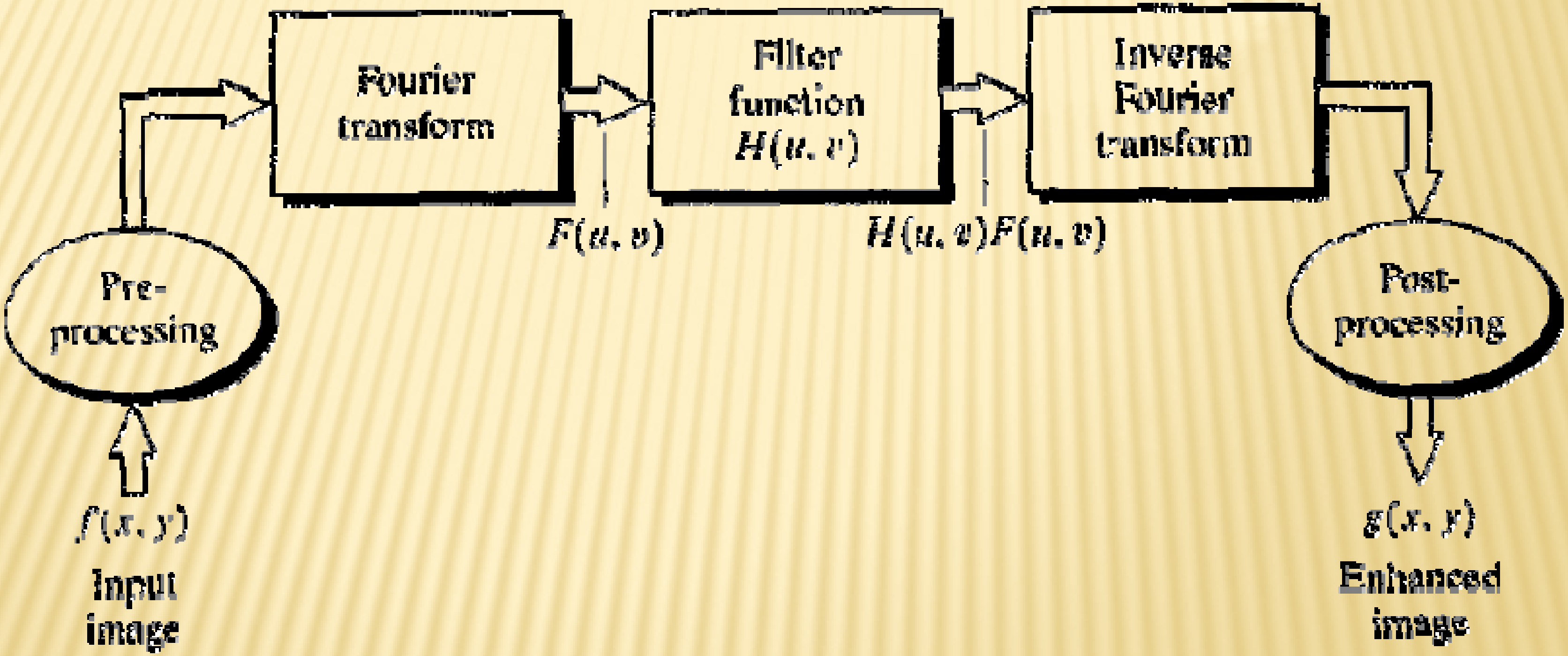
$$f(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F(u,v)e^{j2\pi(ux/M+vy/M)}$$

$$for \quad x = 0,1,2,3,4,\ldots\ldots,M-1$$
$$for \quad y = 0,1,2,3,4,\ldots\ldots,N-1$$

SPATIAL VS FREQUENCY DOMAIN

$$f(x, y) * h(x, y) \leftrightarrow F(u,v)H(u,v)$$

FILTERING IN FREQUENCY DOMAIN



FILTERING IN FREQUENCY DOMAIN

Filtering in the frequency domain is straightforward. It consists of the following steps:

1. Multiply the input image by $(-1)^{x+y}$ to center the transform, as indicated in Eq. (4.2-21).
2. Compute $F(u, v)$, the DFT of the image from (1).
3. Multiply $F(u, v)$ by a *filter* function $H(u, v)$.
4. Compute the inverse DFT of the result in (3).
5. Obtain the real part of the result in (4).
6. Multiply the result in (5) by $(-1)^{x+y}$.

MATLAB LAB FUNCTIONS

- fft2
- ifft2
- fftshift
- real
- imag
- abs
- colormap
- imshow

TASK 1

1. Take sample images and Calculate FFT2.
2. Calculate Magnitude or Spectrum of Fourier and display.
3. Calculate Phase Spectrum and display.
4. Calculate the Inverse FFT2and display.
5. Observe the Changes

TASK 2

1. Take the sample image of cameraman.tif
2. Calculate the FFT2, Magnitude Spectrum and Phase.
3. Keep the magnitude same and Change the Phase to zero.
4. Calculate the inverse fft2.
5. Note the Changes in image.

TASK 3

1. Take the sample image of cameraman.tif
2. Calculate the DFT, Magnitude Spectrum and Phase.
3. Keep the phase same and Change the magnitude unity.
4. Reverse back to the spatial using Inverse DFT.
5. Note the Changes in image.

TASK 4

1. Take sample images
2. Take another sample.
3. Calculate Magnitude or Phase Spectrum of Fourier.
4. Swap the Phase value
5. Reverse back to the images using Inverse DFT.
6. Observe the Changes

TASK 5

1. Take sample images
2. Take the any smoothing Filter
3. Calculate fft2 of both.
4. Multiple the corresponding values both.
5. Calculate the inverse fft2 of resultant.
6. Observe the Changes

TASK 6

1. Take sample images
2. Take the any Sharpening Filter
3. Calculate fft2 of both.
4. Multiple the corresponding values both.
5. Calculate the inverse fft2 of resultant.
6. Observe the Changes

TASK 6

```
im = zeros(512, 512);
im((256-64):(256+64),(256-64):(256+64)) = 1;
```

1. Calculate fft2 of image.
2. Auto correlate the result.
3. Calculate the inverse fft2 of resultant.
4. Observe the Changes