INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Electronics & Electrical Communication Engineering

M.Tech. [First year]

Vision and Intelligent Systems
(VIS)

EC69505 — Image Processing Laboratory

Experiment Number:- 3

Frequency Domain Transformation

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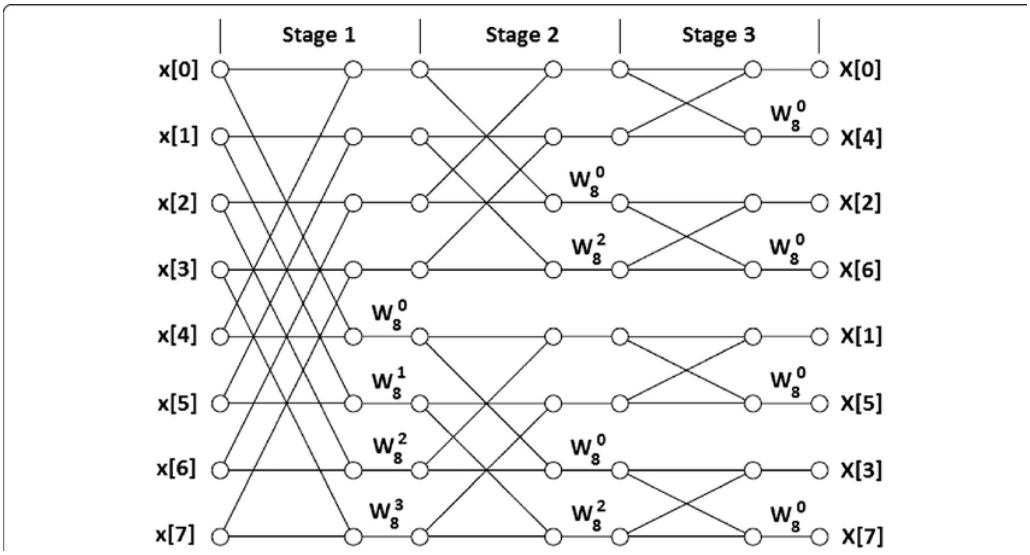
- # Introduction

Problem Statement: To write a C++ modular program, for computing Fast Fourier Transform (FFT) and inverse FFT of an Image with any random spatial dimension. When the Input is An Image and Output is Visualization of Magnitude and phase spectrum of that image. This experiment aims to compute Fast Fourier Transform (FFT) and inverse FFT of an image with any random spatial dimensions.

A Fourier transform (FT) is a mathematical transform that decomposes functions depending on space or time into functions depending on spatial frequency or temporal frequency. In other words, Fourier Transform decomposes an imageinto its sine and cosine components varying amplitudes and phases. The output of the transformation represents the image in the frequency domain, while the input image is the pixel domain or spatial domain equivalent. In the Fourier domain image, each point represents a particular frequency contained in the spatial domain image.The Fourier Transform is used in a wide range of applications, such as image analysis,image filtering, image reconstruction and image compression.

Fast Fourier transform: that is, the use of computer to calculate the discrete Fourier transform (DFT) efficient, fast calculation method collectively, referred to as FFT. The use of this algorithm can greatly reduce the number of multiplications required by the computer to calculate the discrete Fourier transform. In particular, the more the number of sampling points N to be transformed, the more significant the savings in FFT algorithm calculation.



8 point DIF FFT

- **Algorithm**

1. The pixel matrix is extracted using the imread command.

2. We then do the padding, if required after checking the pixel matrix size.
3. We then apply FFT algorithm on the pixel matrix in the raster scan fashion, first row is computed and then column, i.e. two times FFT is applied on each pixel. The coefficients obtained are then Fast Fourier Transformed Column Wise. This gives usrequired FFT of the image.

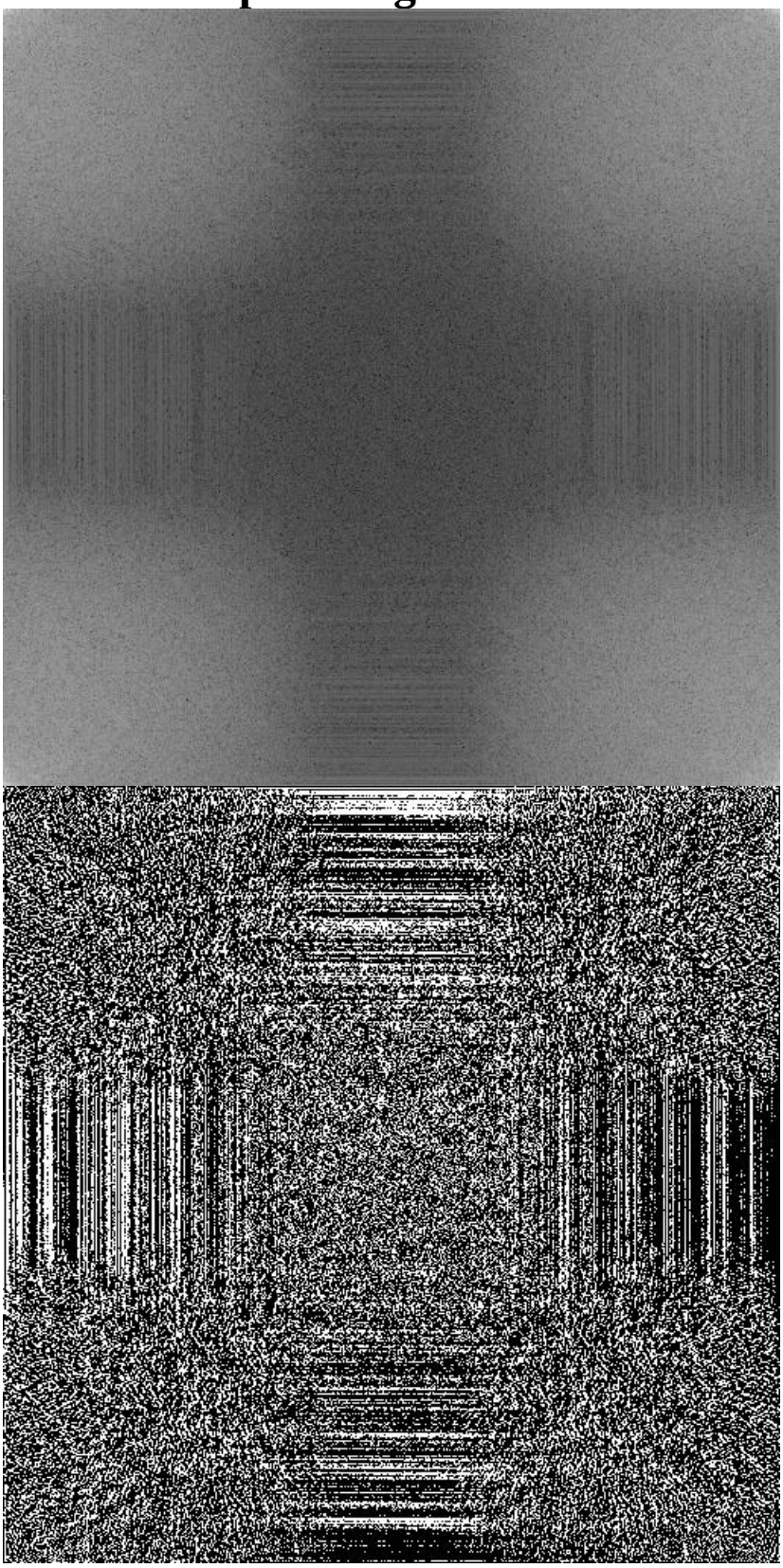
4. For Inverse FFT, we repeat steps 3 after scaling down the coeffients by size of thearray and conjugating the twiddle factor.

5. To plot the phase and the magnitude of the FFT, we use the in-built class functions of the "complex" class available in C++.

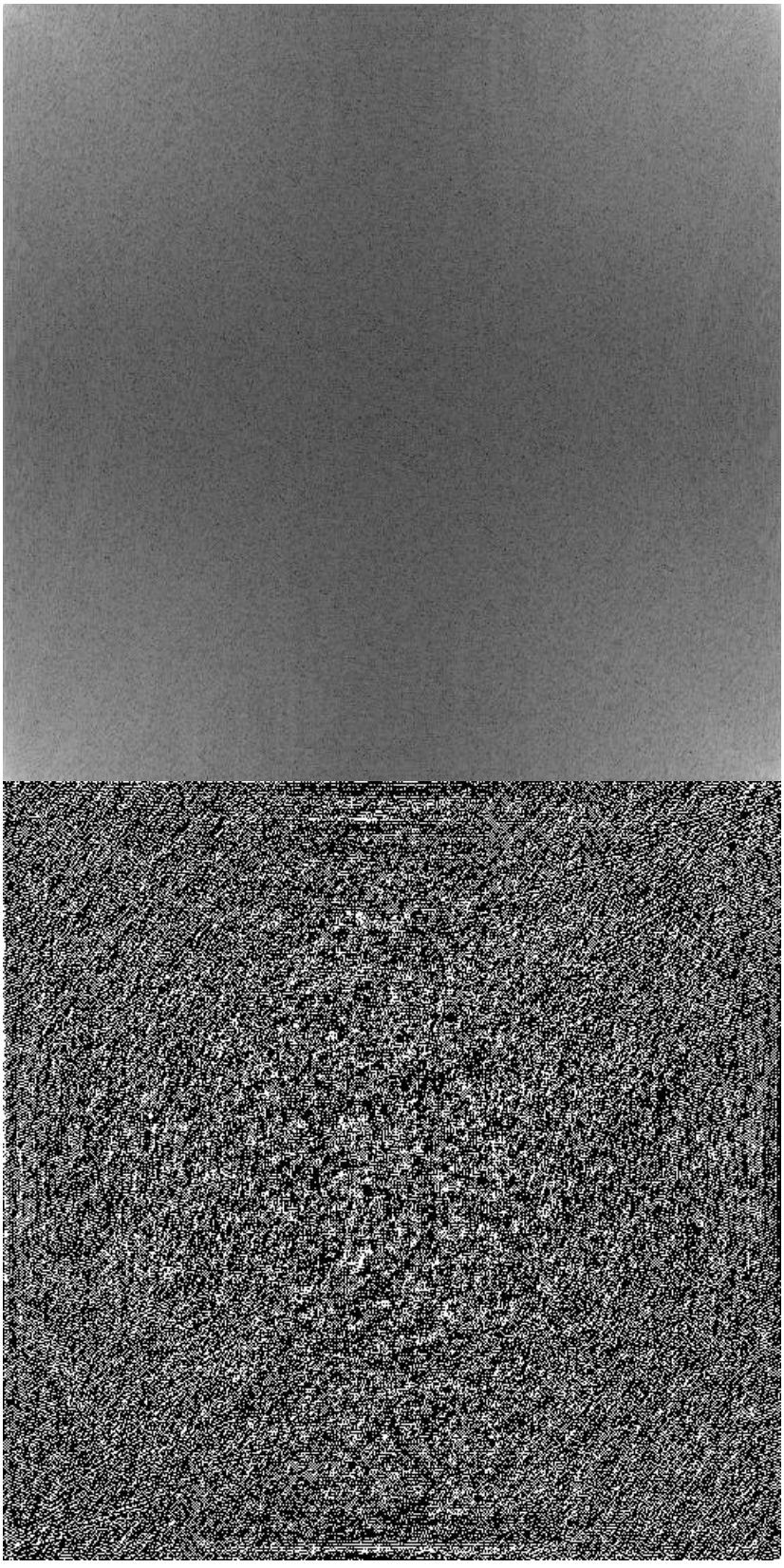
6. We need to normalise the high absolute values obtained from the complex FFT coefficients. For this, we plot the magnitude on log scale.

7. Finally we use imwrite command to print the output image.

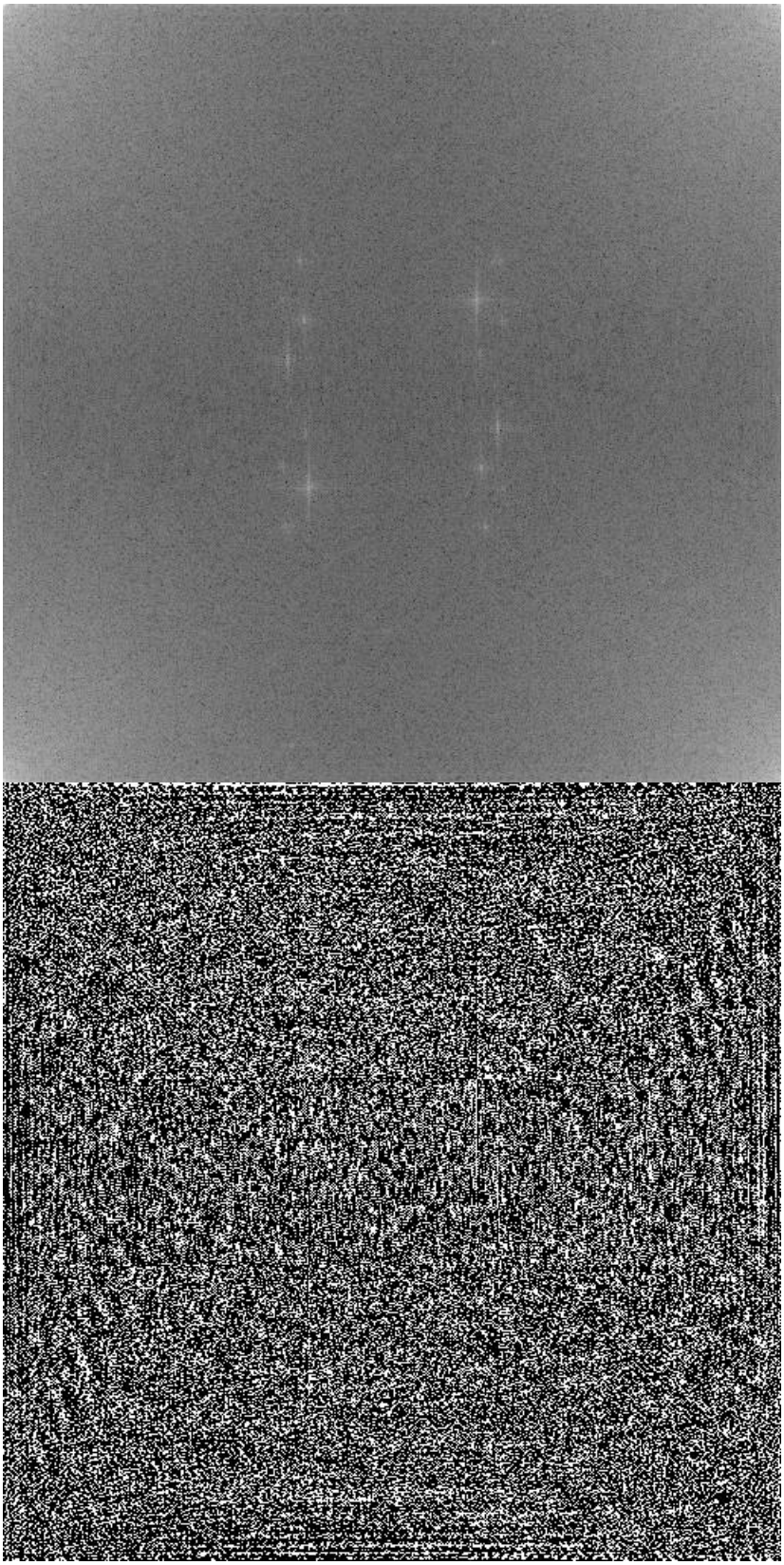
- **Output Images**



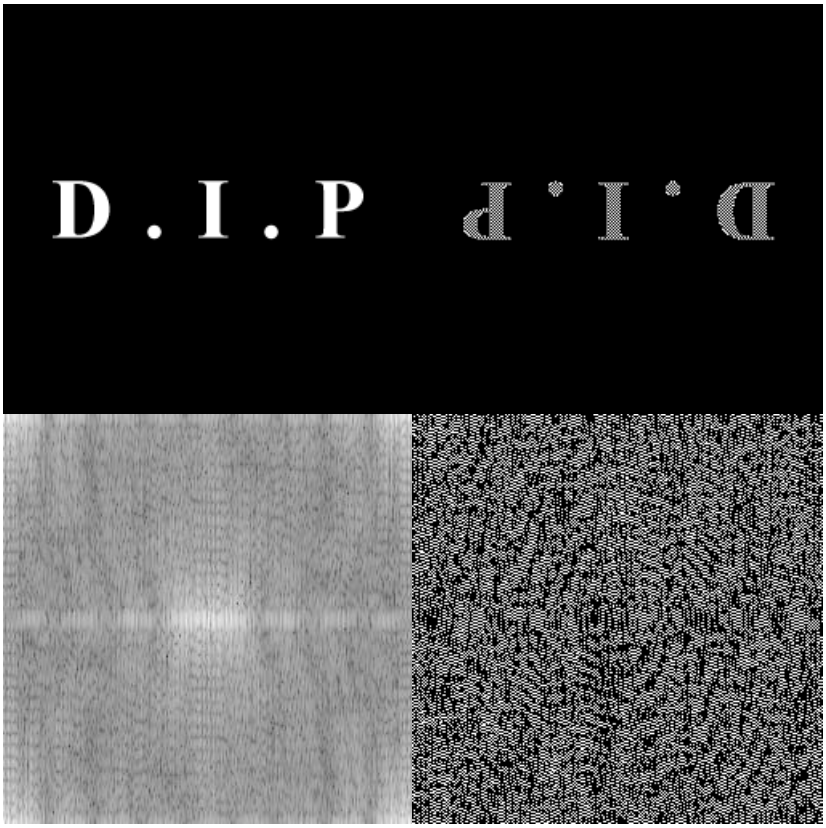
Mandril_Magnitude and Mandril_Phase



JETPLANE magnitude and phase



Lake magnitude and phase



DIP_input, DIP ifft, Dip magnitude and DIP phase

- ## Discussion

1. If the coefficient of pixel is very high then the image was getting black. So, we apply a logarithmic transformation to the image.

2. High magnitude of low frequency components is observed as in all of our perceivable world images, Low Frequency is the largest component of the image.

3. After performing the second part of experiment on DIP image, we get an image that is upside down and lower in intensity.

- ## References:

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3. https://www.l3harrisgeospatial.com/docs/backgroundfastfouriertransform.html
4. https://en.wikipedia.org/wiki/Fourier_transform