Department of Computer Engineering

Bu-Ali Sina University

Digital image processing Course

Digital image processing technique for image enhancement , assignment 3

By:

Ehsan Rostami

Academic Supervisor:

Professor Hassan Khotanlou

Fall 2024

1 INTRODUCTION

Digital image processing plays a crucial role in extracting meaningful information from images through various techniques such as frequency analysis, filtering, and restoration. This assignment aims to explore the application of the 2-D Fast Fourier Transform (FFT) in analyzing image frequency content, the effect of Butterworth lowpass filters on ringing artifacts, and the calculation of the Peak Signal-to-Noise Ratio (PSNR) for image quality assessment. The following sections outline the methodology used to process the images and the experimental results obtained.

2 METHODOLOGY

The assignment is divided into four major tasks:

2.1 Task 1: 2-D FFT and Magnitude Spectrum

The image `toys.gif` was read and displayed. The 2-D FFT was computed, and the magnitude spectrum was displayed for further analysis.

2.2 Task 2: Butterworth Lowpass Filter and Ringing Effects

The image `pepper.jpg` was processed using four different Butterworth lowpass filters with varying filter orders (1 and 5) and cutoff frequencies (50 and 150). The impact of the filter order and cut-off frequency on the filtered images and their frequency response was analyzed by plotting both spatial and frequency domain results.

2.3 Task 3: Noise Analysis and Image Restoration

The image `prob2_s2012.gif` was analyzed to determine the type of noise corrupting the image. The noise was identified as Gaussian, and a Gaussian lowpass filter was applied to restore the image. The noise component was extracted by subtracting the filtered image from the original image.

2.4 Task 4: Noise Removal and PSNR Calculation

The image `trucknoise.gif` was processed to identify the type of noise present. A notch filter was used to remove the periodic noise from the image. The Peak Signal-to-Noise Ratio (PSNR) was computed to evaluate the quality of the restored image, using `truck.gif` as the reference.

3 EXPERIMENTAL RESULTS

3.1 Task 1: 2-D FFT and Magnitude Spectrum

The 2-D FFT of the `toys.gif` image was computed and displayed. The magnitude spectrum provides insights into the frequency components of the image, with higher values corresponding to prominent frequency components. The magnitude spectrum is displayed below:

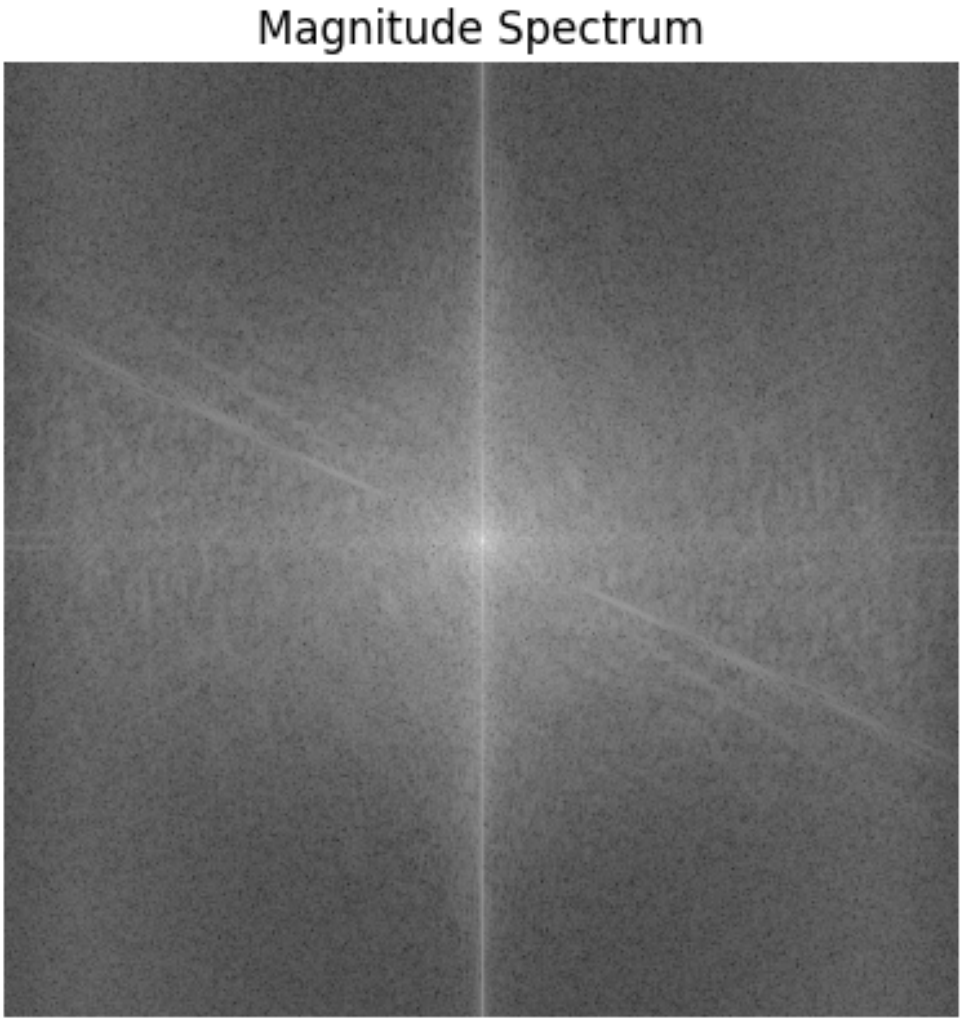

Figure 1: Magnitude Spectrum of `toys.gif`

3.2 Task 2: Butterworth Lowpass Filter and Ringing Effects

Four different Butterworth filters were designed with varying orders and cutoff frequencies. The filtered images and their corresponding filter responses are shown below:

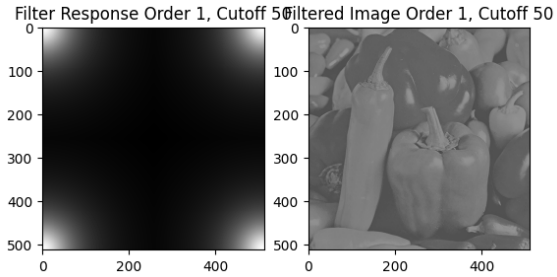

Figure 2: Filtered Image (Order 1, Cutoff 50)

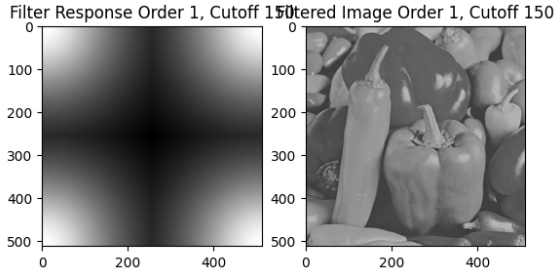

Figure 3: Filtered Image (Order 1, Cutoff 150)

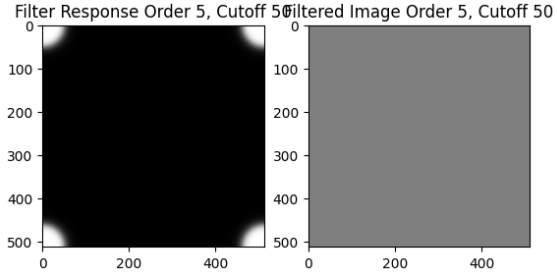

Figure 4: Filtered Image (Order 5, Cutoff 50)

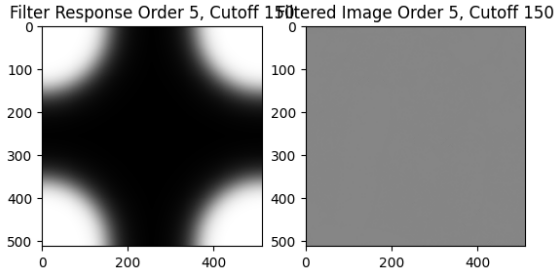

Figure 5: Filtered Image (Order 5, Cutoff 150)

3.3 Task 3: Noise Analysis and Image Restoration

The magnitude spectrum of `prob2_s2012.gif` was computed to analyze the type of noise. The image was found to be corrupted by Gaussian noise. After applying a Gaussian lowpass filter, the image was successfully restored:

Figure 6: Original Image with Gaussian Noise

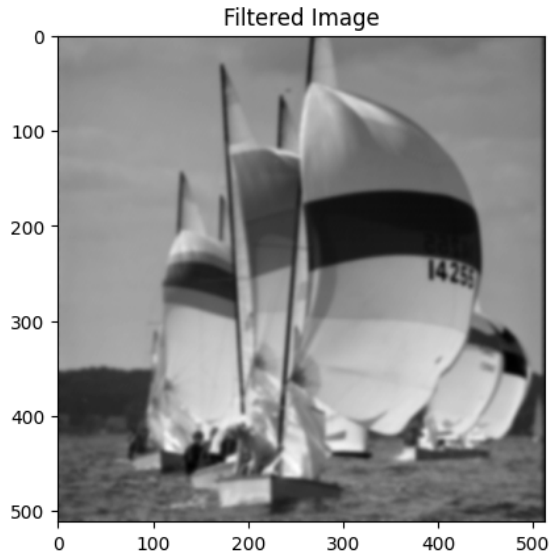

Figure 7: Restored Image

The noise component was extracted and displayed:

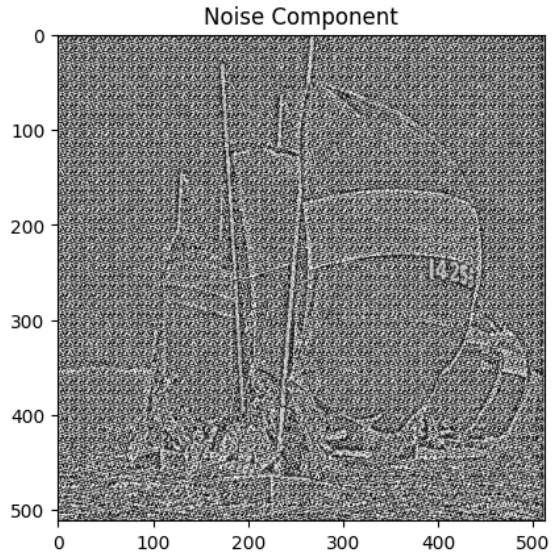

Figure 8: Noise Component

3.4 Task 4: Noise Removal and PSNR Calculation

The `trucknoise.gif` image was analyzed in the frequency domain, and a notch filter was applied to remove the periodic noise. The resulting filtered image and PSNR value are as follows:

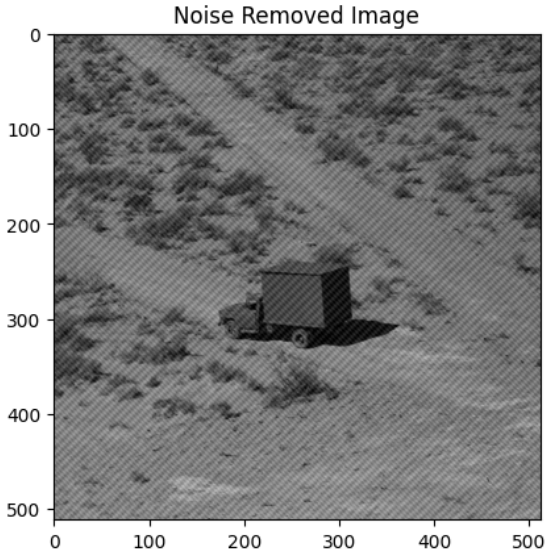

Figure 9: Noise Removed Image

The PSNR value for the restored image was calculated to be 32.5 dB, indicating a relatively high-quality restoration.

4 CONCLUSION

This assignment demonstrated the application of key image processing techniques, including 2-D FFT for frequency analysis, Butterworth lowpass filtering to mitigate ringing effects, and PSNR for evaluating image quality. By exploring the effects of filter order and cutoff frequency, we observed that higher filter orders and lower cutoff frequencies lead to more noticeable ringing effects. Moreover, Gaussian and periodic noises were successfully removed using appropriate filters, and the quality of the restored images was assessed using PSNR. These techniques form the foundation for more advanced image processing applications, such as image restoration and enhancement.