Department of
Robotics and Mechatronics Engineering

Lab report

DIGITAL SIGNAL PROCESSING (CSE-401)

Name of the Experiment: Filter design in frequency domain.

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4^{th} year 1^{st} semester

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Experiment no. 6

Name of the experiment

Filter design in frequency domain.

Objectives

- To learn how to use filters.
- To understand the concepts of High pass filter and Low Pass filter.
- To learn to design filters using cutoff frequency.
- To sharpen or blur an image using filters in frequency domain.

Theory

Fast Fourier Transform maps a two dimensional image from spatial domain to the frequency domain. As a result we obtain a matrix of complex numbers.

A window of circular shape of radius equal to the cutoff frequency can cut off the frequency components outside the circle. Thus this window acts as a *Low Pass Filter*. If this filtered frequency components are again mapped to spatial domain using Inverse Fast Fourier Transform we get a an image which is blurred out. The frequency of pixel values are higher at the edges. So, the edges are smoothed and thus we get a blurred image.

Again, if a window is taken which allows frequency components outside a circle of radius equal to cutoff frequency we get higher frequency values only. If the filtered frequency components are mapped to spatial domain using Inverse Fourier Transform we get only the edges of the images. The threshold of edge remaining can be controlled by the radius of the circle of the filter i.e. by changing the cut-off frequency. Thus, in such a manner *High Pass Frequency* is actualized.

Implementation Code

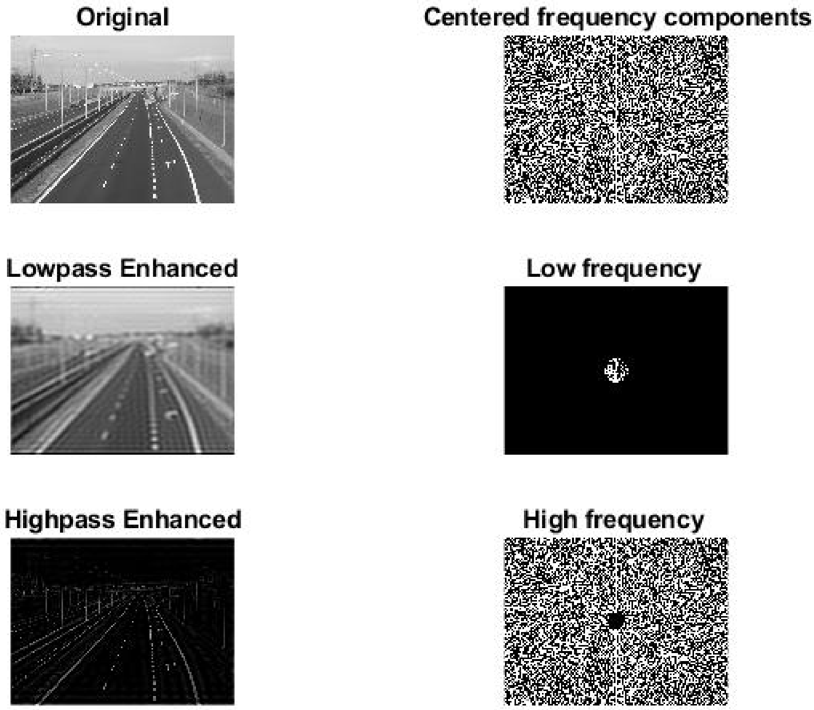
main.m

```
clc; clear; close all;
Original = imread('road.jpg');
Original = rgb2gray(Original);
```

```
I = double(Original)/255;
[M,N] = size(I);
subplot(321);imshow(I);
title('Original');
for i=1:M
    for j=1:N
        I(i,j) = I(i,j)*(-1)^(i+j);
    end
end

I_fft = fft2(I);
subplot(322);imshow(I_fft);
title('Centered frequency components');

%% Low pass filter

cutoff_frequency = 30;
H_lowpass = zeros(M,N);

for i=1:M
    for j=1:N
        if norm([M/2 N/2]-[i j]) < cutoff_frequency
            H_lowpass(i,j)=1;
        end
    end
end

I_lowpass_F = I_fft.*H_lowpass;
subplot(324);imshow(I_lowpass_F);
title('Low frequency ');
LowPassed_image = ifft2(I_lowpass_F);
for i=1:M
    for j=1:N
        LowPassed_image(i,j) = LowPassed_image(i,j)*(-1)^(i+j);
    end
end
subplot(323);imshow(LowPassed_image);
title('Lowpass Enhanced');


%% High pass filter

cutoff_frequency = 20;
```

```
H_highpass = zeros(M,N);

for i=1:M
    for j=1:N
        if norm([M/2 N/2]-[i j]) > cutoff_frequency
            H_highpass(i,j)=1;
        end
    end
end

I_highpass_F = I_fft.*H_highpass;
subplot(326);imshow(I_highpass_F);
title('High frequency ');
HighPassed_image = ifft2(I_highpass_F);
for i=1:M
    for j=1:N
        HighPassed_image(i,j) = HighPassed_image(i,j)*(-1)^(i+j);
    end
end
subplot(325);imshow(HighPassed_image);
title('Highpass Enhanced');
```

Result



High Pass Filter and Low Pass Filter Visualized