Tuna Okçu 22002940

All of the images in order as well as the MATLAB code are presented at the end of the report.

1)

(i) It looks like the image is in motion, being shaken horizontally, which makes sense given that the filter averages over the columns(i.e. horizontally), giving it a blurry look.

(ii) The details get less discernable as M increases and the picture gets more blurry(makes sense given that increasing M decreases the weight of the original pixel, adding more pixels to average over).

(iii)

The opposite effect can be observed when the filter is applied over the rows instead:

Vertical “motion”(filter applied over rows)

Horizontal “motion”(filter applied over columns)

(iv)

These plots indicate how much of an effect a particular frequency has on the output of the system: if the magnitude is high for a particular frequency, the frequency has a great impact(and the rest are “filtered out”). We can see that w = 0 has the greatest weight and the weight decreases as w approaches pi and -pi. As M increases, the curves get thinner and the weights of the periphery decrease.

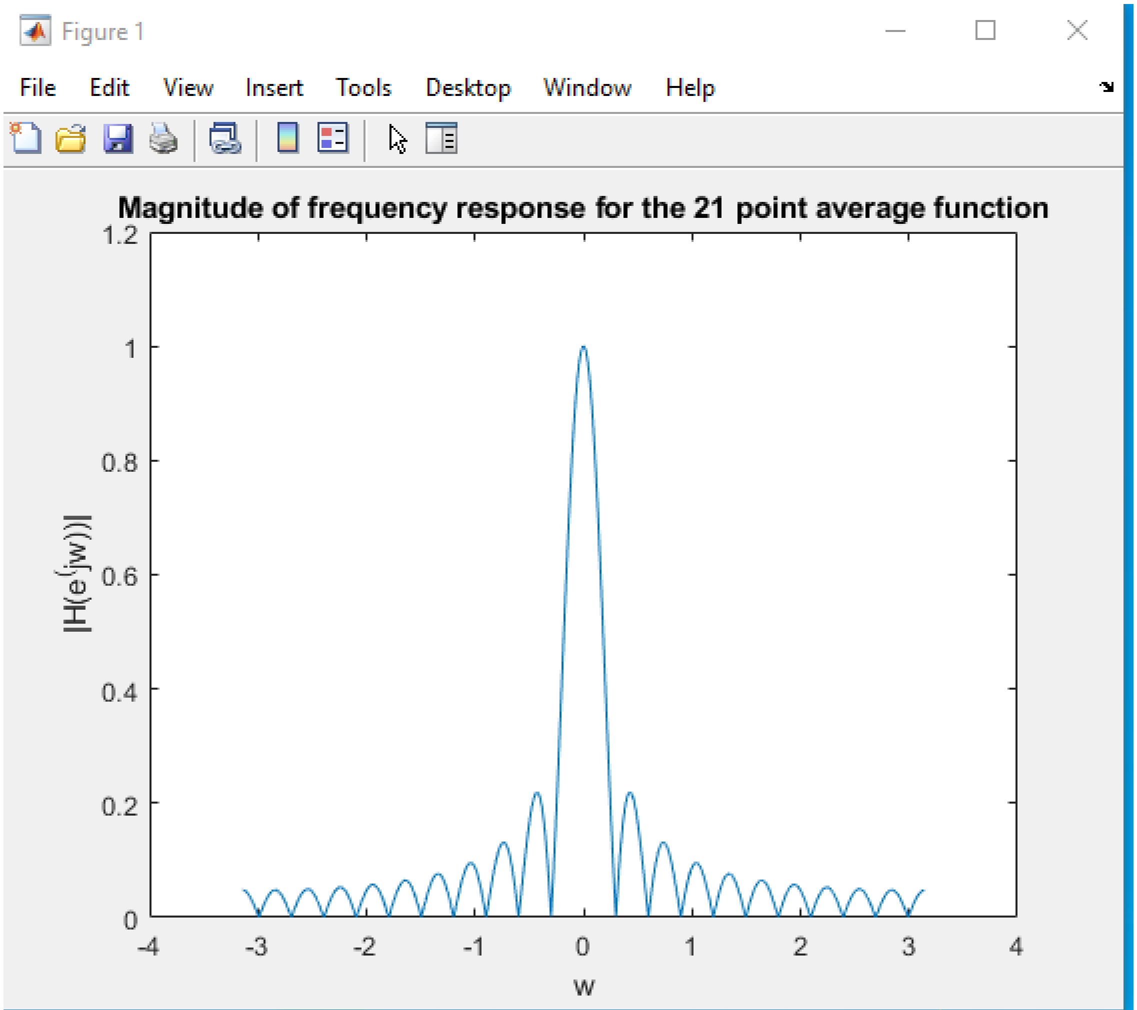
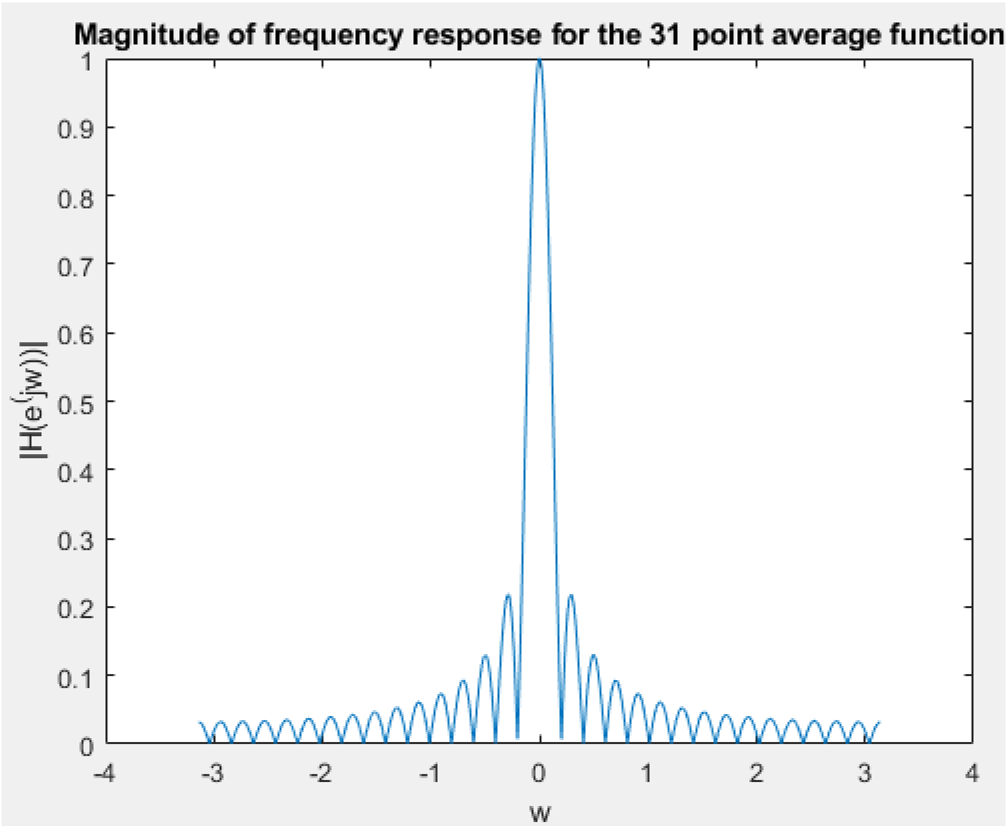


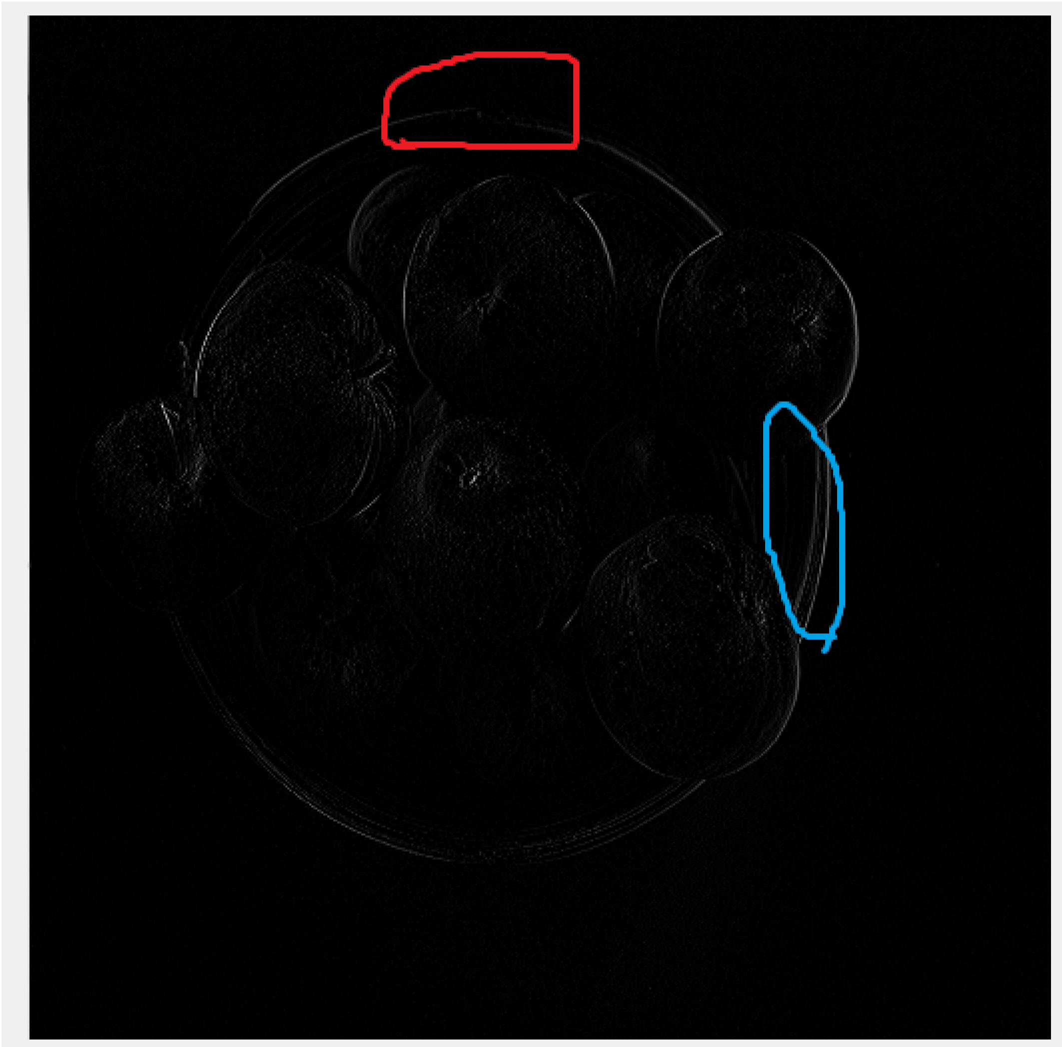
Figure 1
File Edit View Insert Tools Desktop Window Help
Magnitude of frequency response for the 21 point average function
|H(e^(jw))|
w
1.2
1
0.8
0.6
0.4
0.2
0
-4
-3
-2
-1
0
1
2
3
4



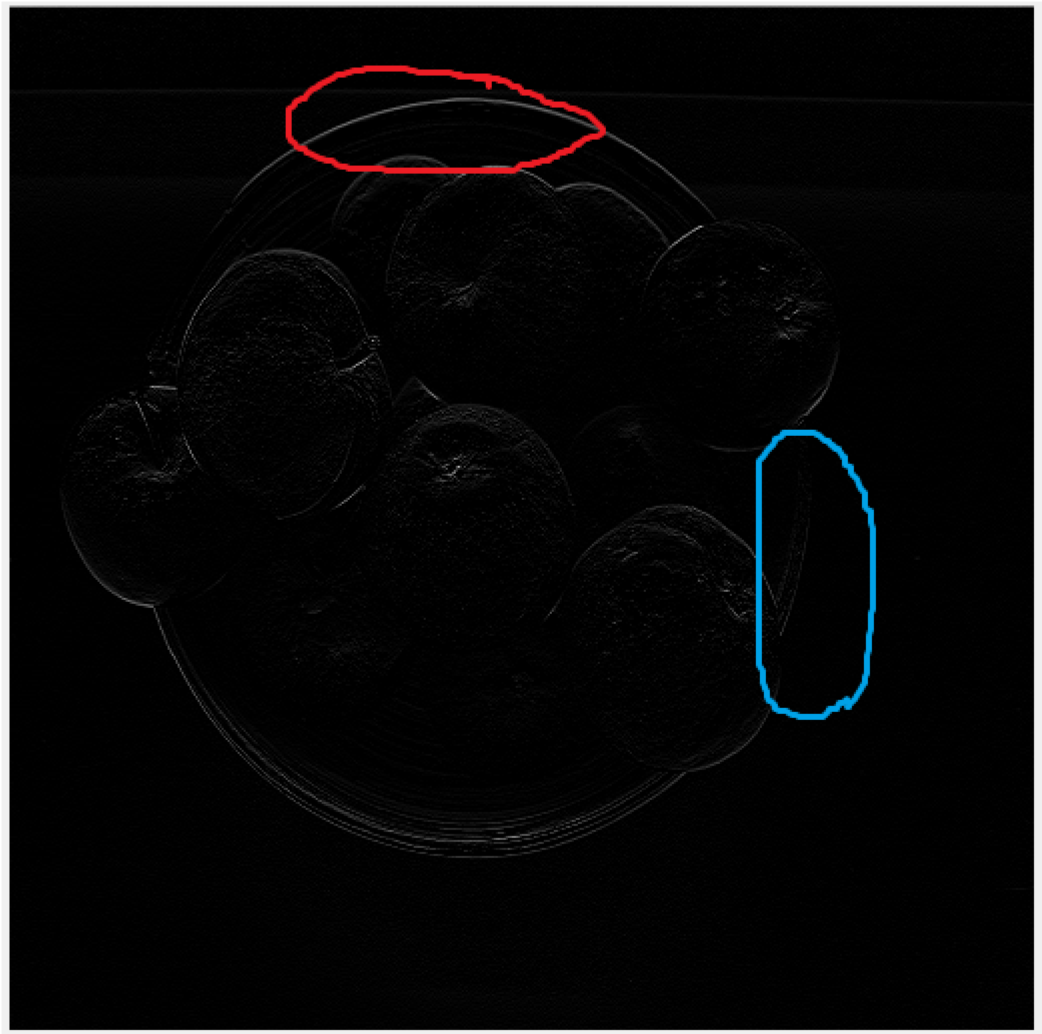
(v)
The edges become more blurry as M increases.

2)
(i)It highlights the edges(where there's a significant difference between x[p, q] and x[p, q-1]) and renders the rest of the image black(since only sharp edges result in a x[p, q]-x[p, q-1] that is significantly greater than 0). Since this is again done over columns, it mostly highlights vertical lines.
(ii) This is to be expected theoretically, since the filter compares how different the current sample is to the last sample, and if the difference is slight(as is to be expected except in the outlines of an image, which can be thought of as discontinuities in an otherwise regular function), the difference will be indiscernible.

(iii)Here's a demonstration showing the difference:

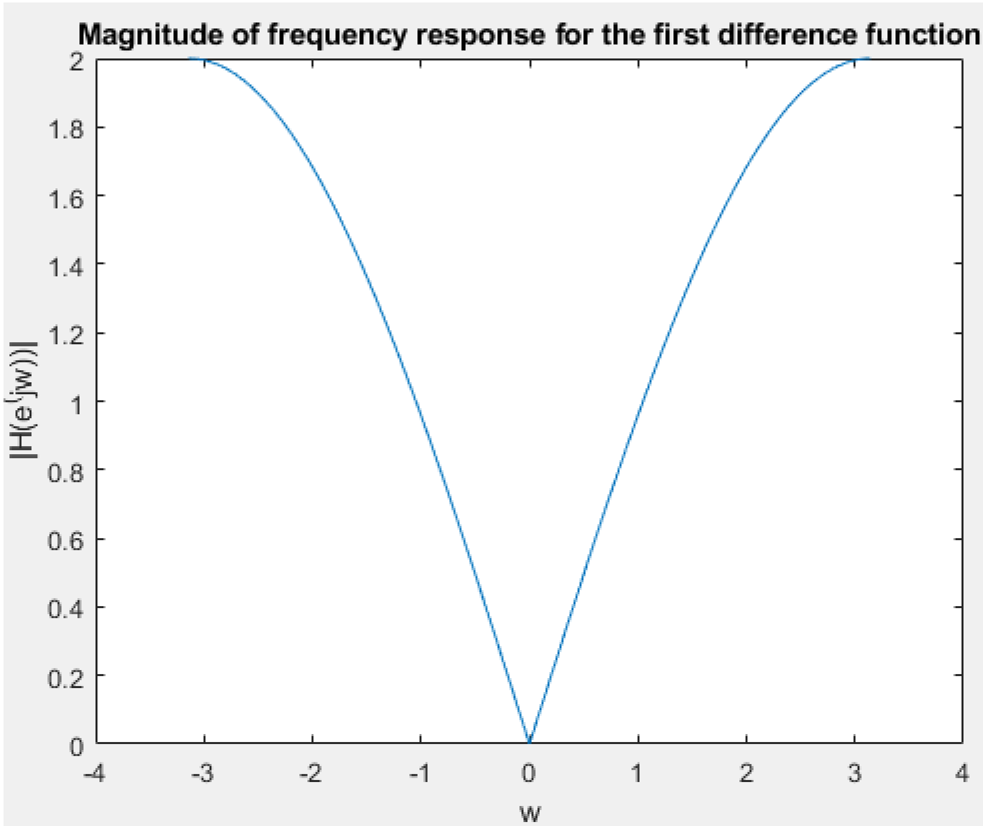


Vertical line rendered invisible by the specified filter(x[p, q] - x[p, q-1]), meanwhile horizontal lines are highlighted

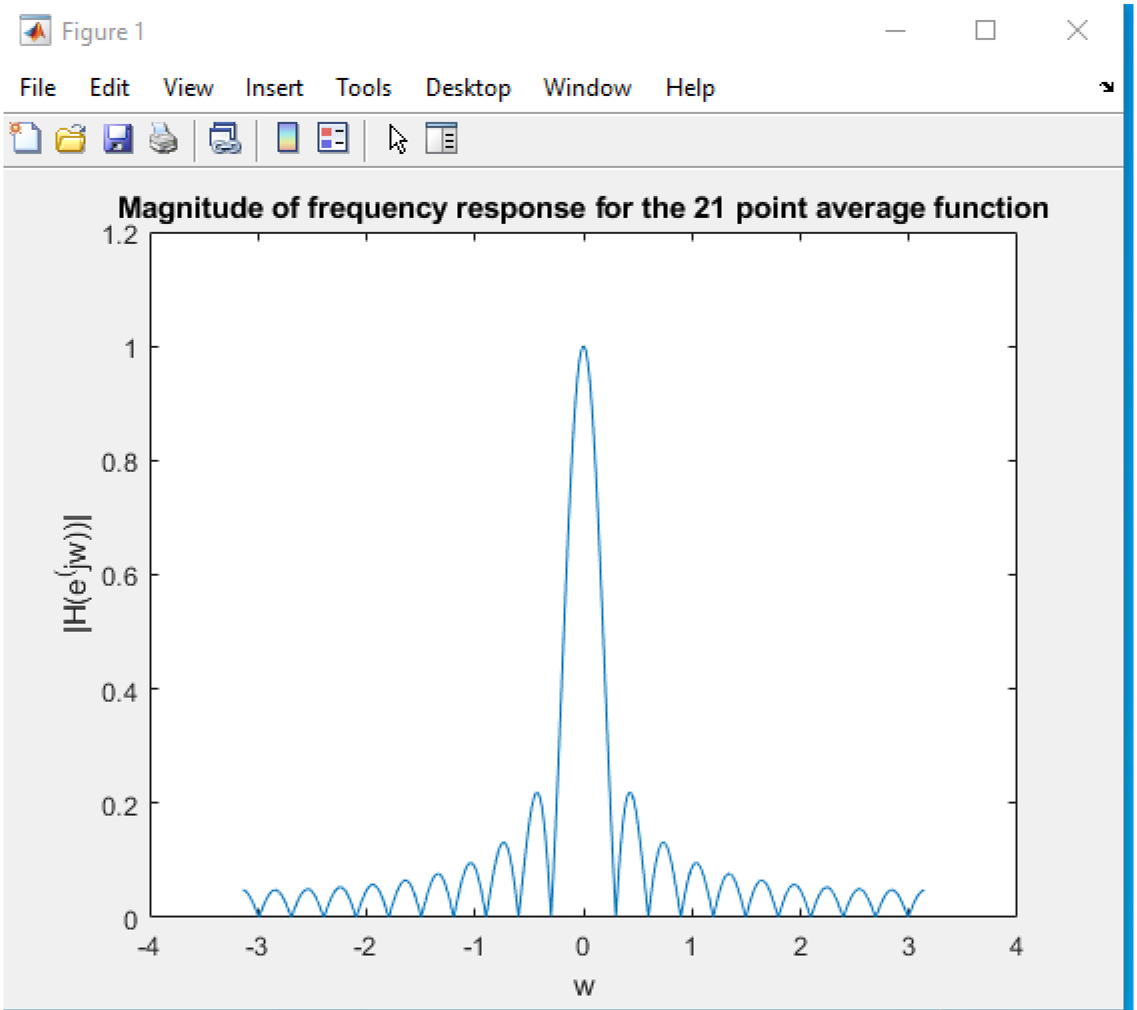


Vertical line rendered invisible by another filter(x[p, q] - x[p-1, q]), meanwhile horizontal lines are highlighted. Note that there are still overlaps between the two filters.

(iv)



Smaller frequencies disappear while larger frequencies get boosted.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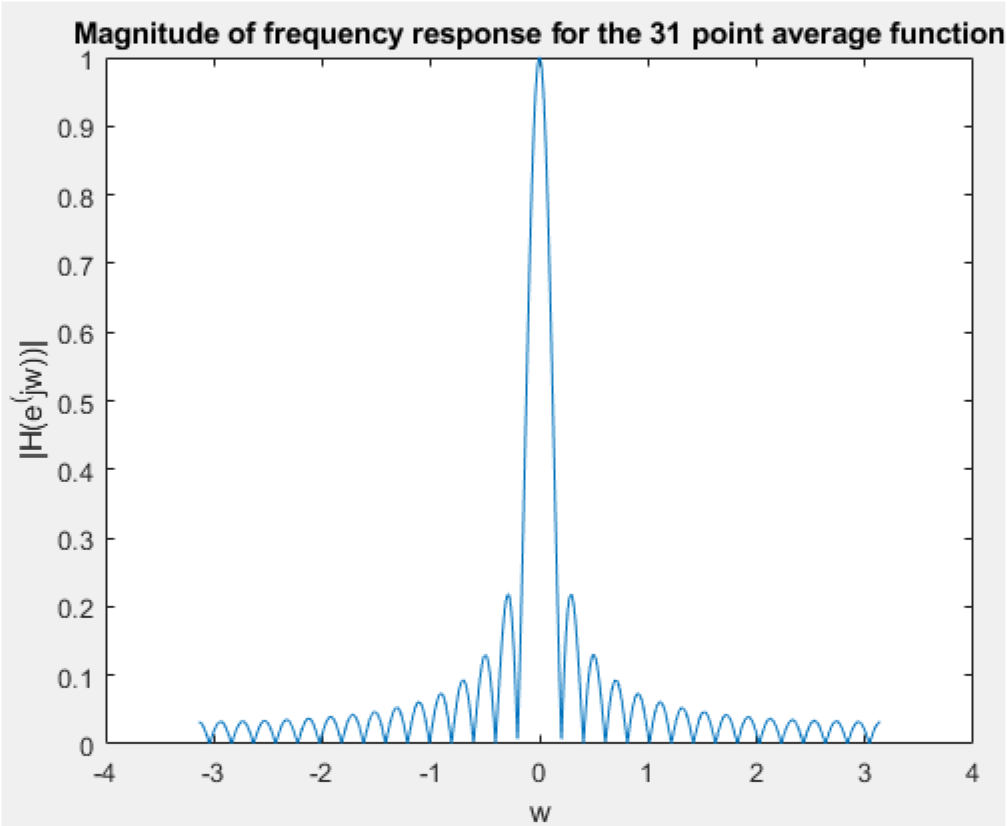
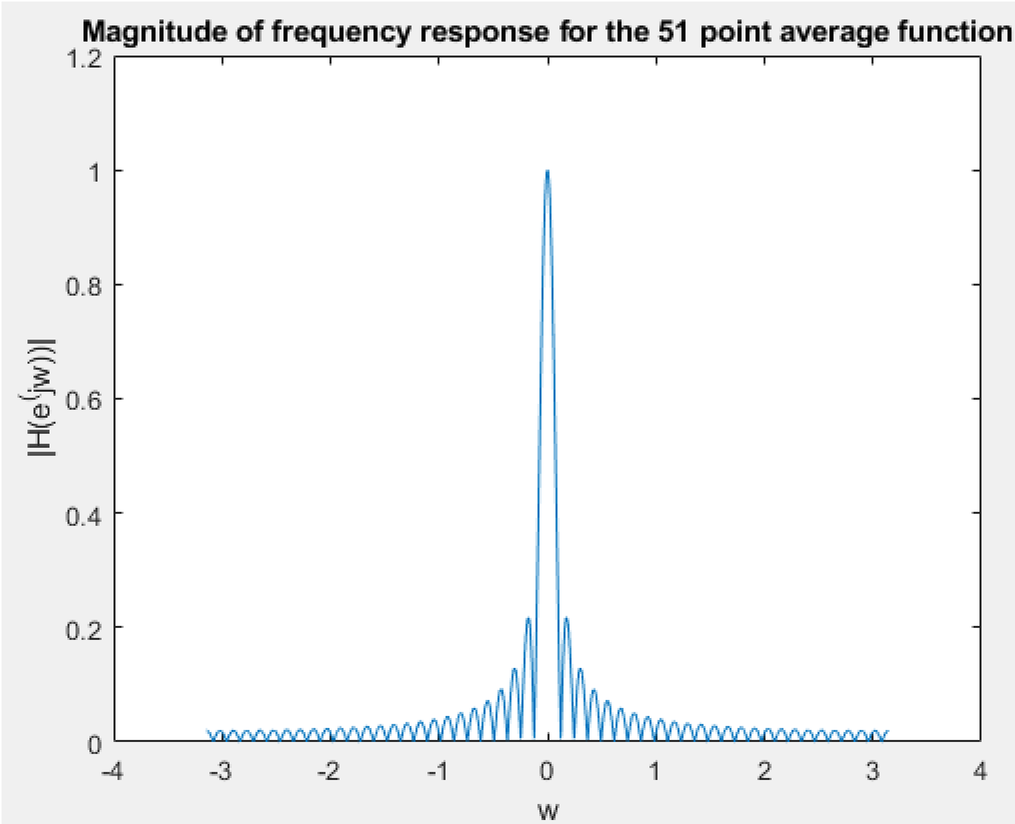
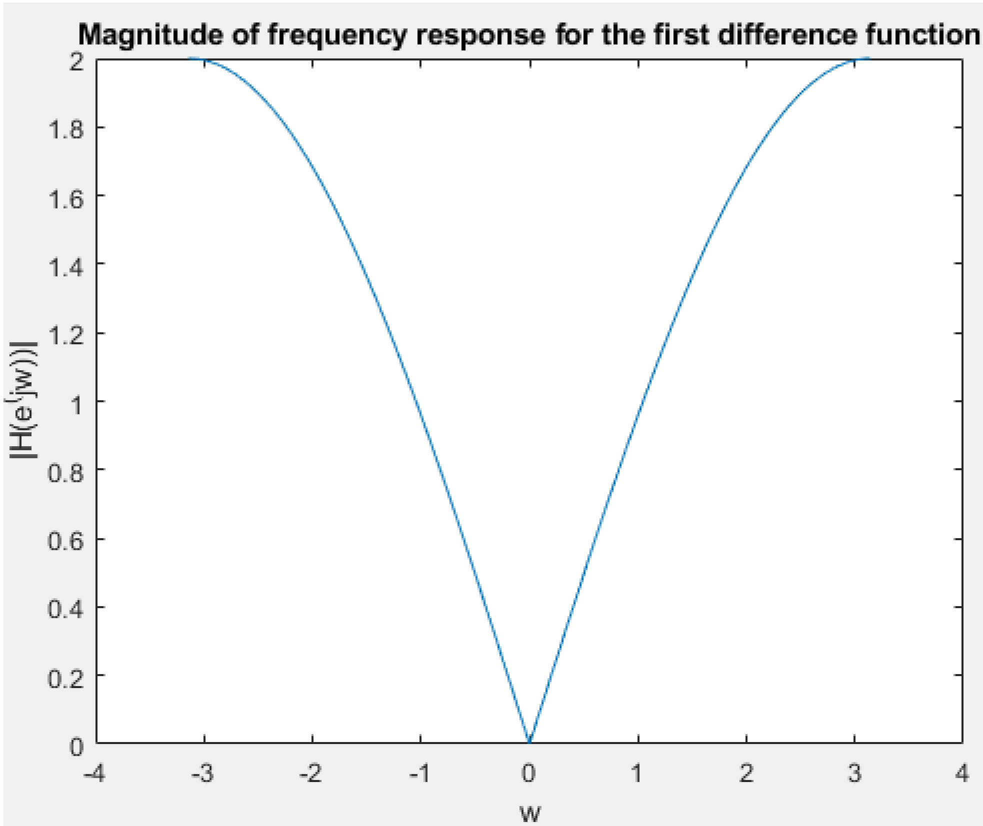
-3
-2
-1
0
1
2
3
4


Magnitude of frequency response for the 31 point average function
|H(e^(jw))|
w
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-4
-3
-2
-1
0
1
2
3
4


Magnitude of frequency response for the 51 point average function
|H(e^(jw))|
w
1.2
1
0.8
0.6
0.4
0.2
0
-4
-3
-2
-1
0
1
2
3
4



Magnitude of frequency response for the first difference function
|H(e^jw))|
w
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-4
-3
-2
-1
0
1
2
3
4

Code:

```
function [] = read_and_filter_image()
    I = imread("Apples.bmp");
    G = mat2gray(I, [0 255]);

    %21, 31, 51
    plot_M_point_average_frequency_response_magnitude(21);
    figure
    imshow(blur_horizontal(G, 21));

    plot_M_point_average_frequency_response_magnitude(31);
    figure
    imshow(blur_horizontal(G, 31));

    plot_M_point_average_frequency_response_magnitude(51);
    figure
    imshow(blur_horizontal(G, 51));
```

```
    plot_first_difference_frequency_response_magnitude();
    figure;
    imshow(highlight_vertical_lines(G));

end


function [] = plot_M_point_average_frequency_response_magnitude(L)
    range = -pi:(pi/1000):pi;
    bb = ones(1, L)/L;
    HH = freqz(bb, 1, range);
    figure
    plot(range, abs(HH));
    xlabel("w");
    ylabel("|H(e^(jw))|");
    title("Magnitude of frequency response for the " +  L + " point average function");
end
%A is a 2d matrix
function filtered = blur_horizontal(A, m)
    filtered = movmean(A, m, 2);
end

%A is a 2d matrix
function filtered = blur_vertical(A, m)
    filtered = movmean(A, m, 1);
end

function [] = plot_first_difference_frequency_response_magnitude()
    start_end = pi;
    range = -start_end:(start_end/2000):start_end;
    HH = 2 * abs(sin(range/2));
    figure
    plot(range, abs(HH));
    xlabel("w");
    ylabel("|H(e^(jw))|");
    title("Magnitude of frequency response for the first difference function");
end

function filtered = highlight_vertical_lines(A)
    filtered = filter([1, -1], 1, A, [], 2);%, dim=2);
end

function filtered = highlight_horizontal_lines(A)
```

```
    filtered = filter([1, -1], 1, A, [], 1);%, dim=2);
end
```