Lab 6 – Image processing – 2D signals

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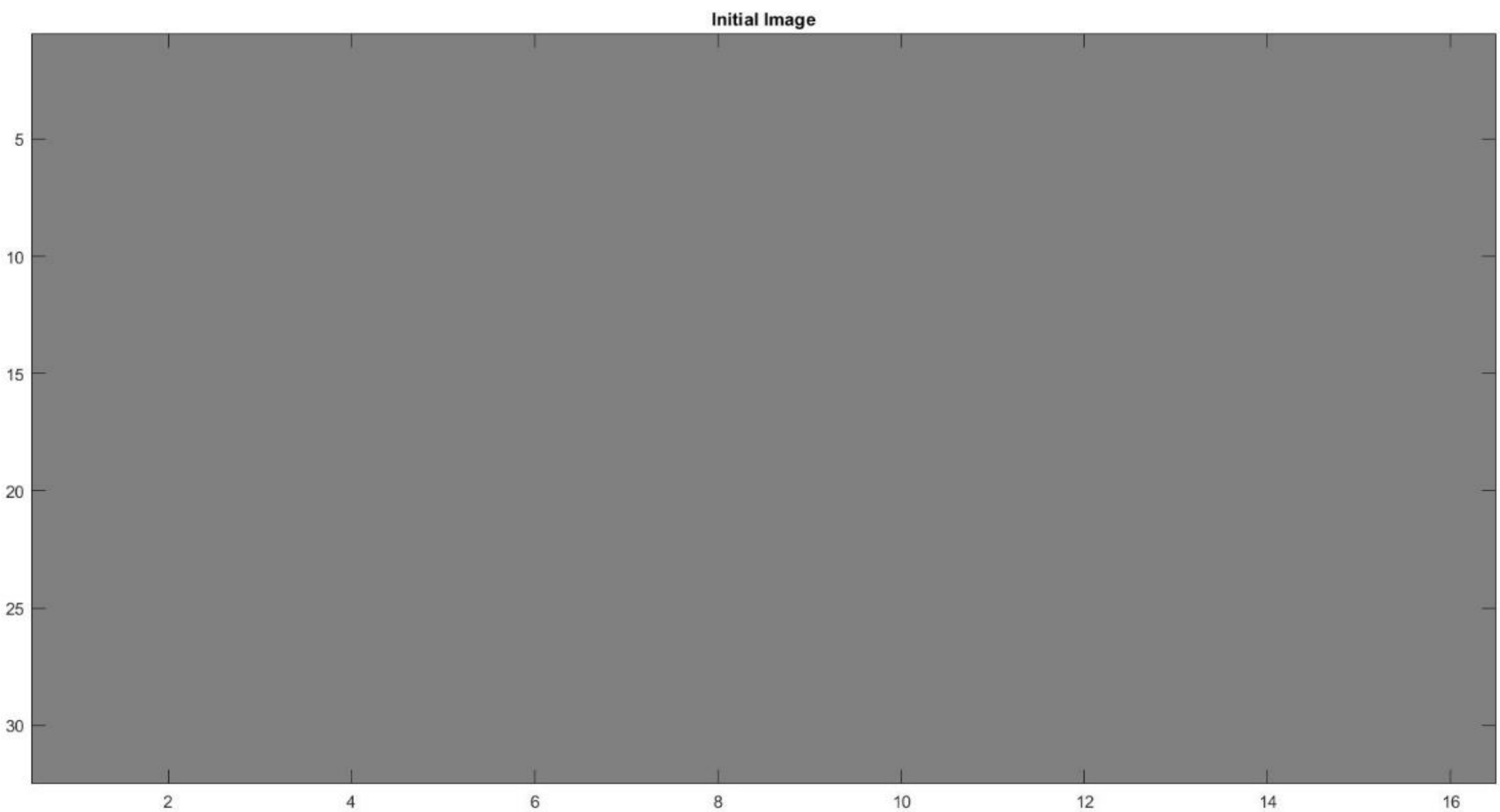
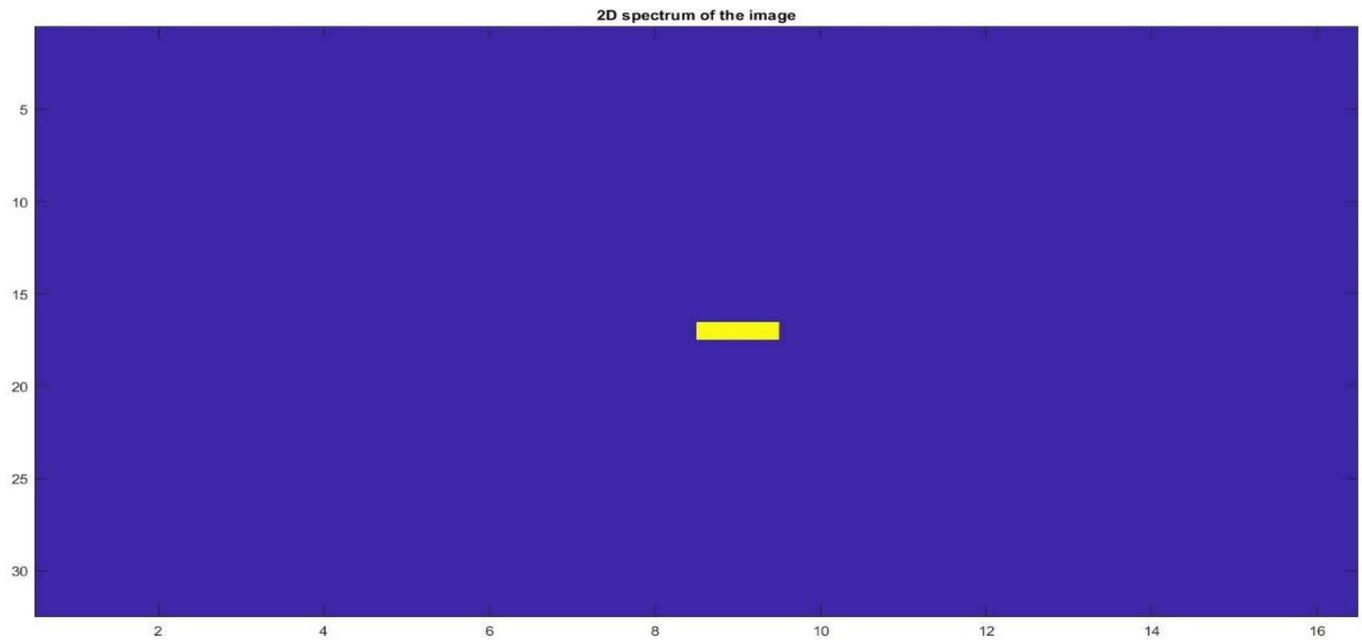
Experiments:

Task 6.2.1

"All-white" image with size 32 x 16 pixels





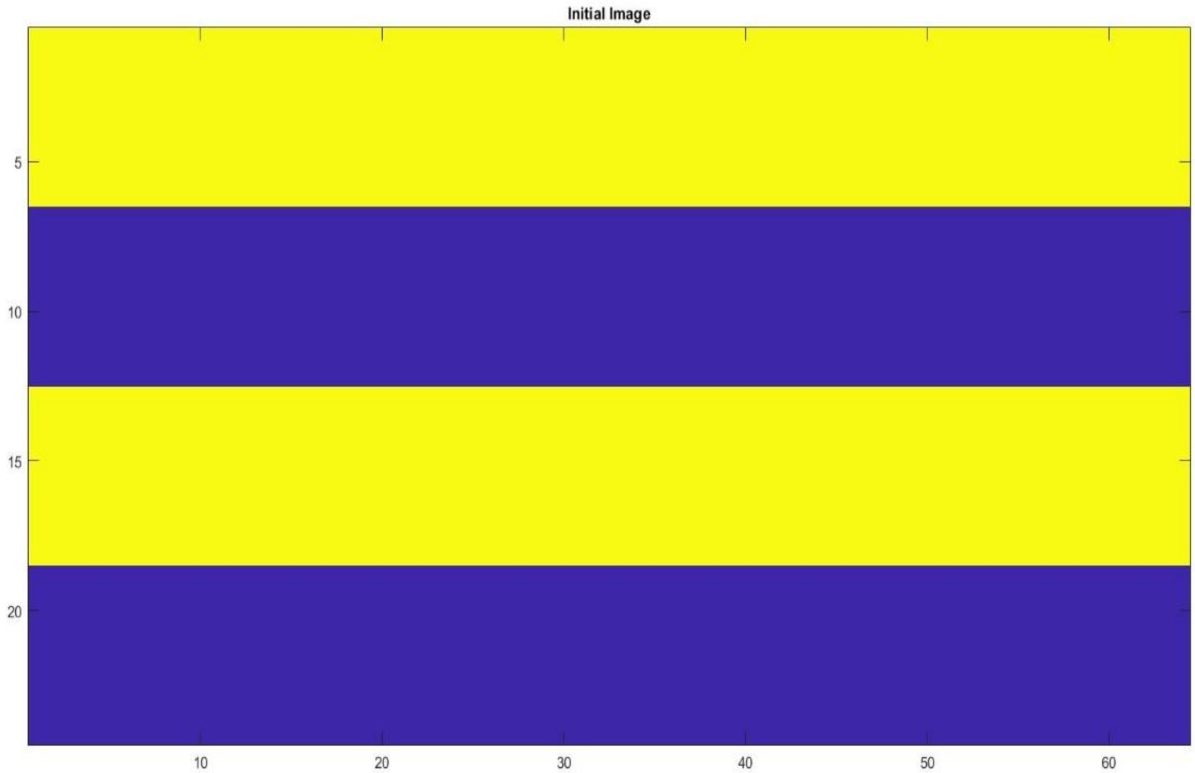
The yellow square in the middle is equal to 32*16, which is the initial frequency being displayed (zero frequency), as we have only the constant component.

Matrix size is 32 x 16 double.

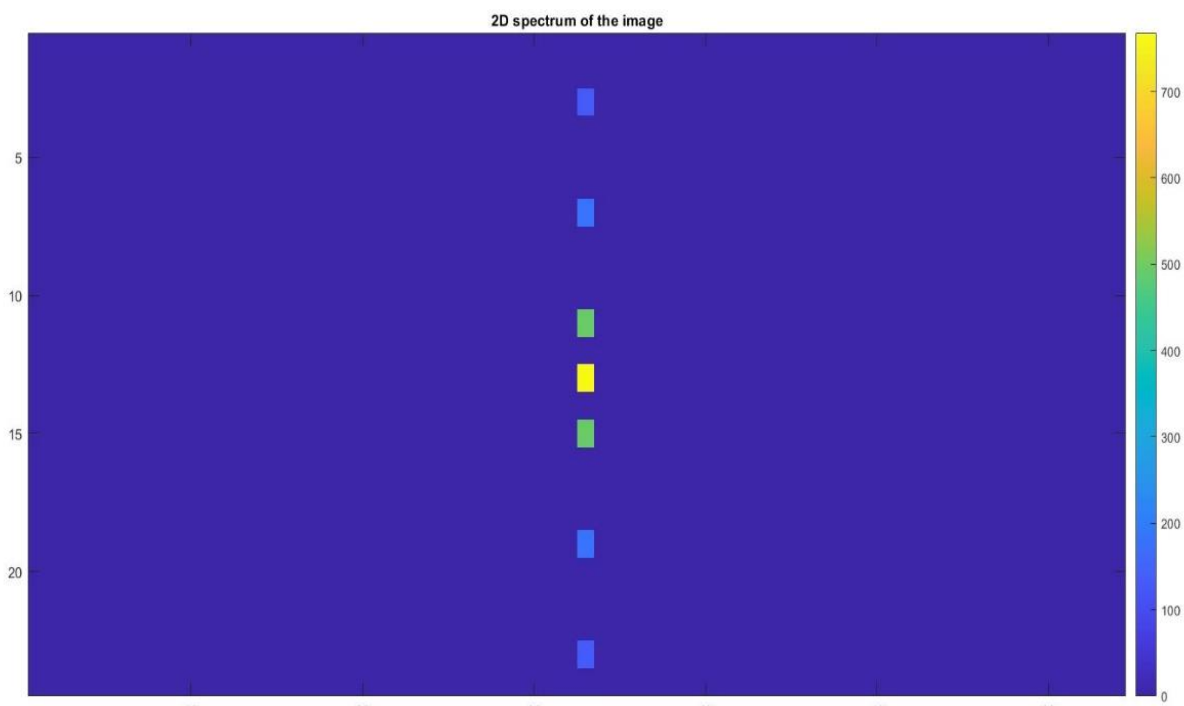
The variables represented on the axes correspond to the dimensions of the image.

Making experiment for images consisting of horizontal lines and chequerboard:

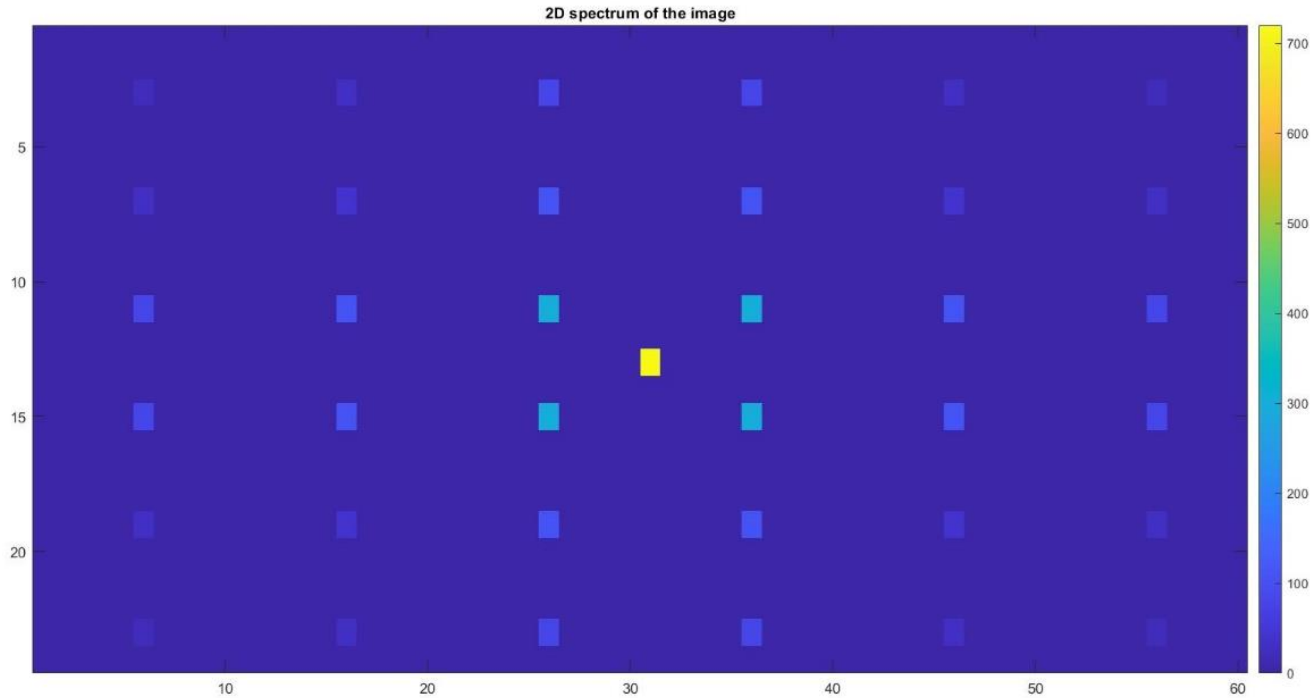
Horizontal lines with low frequency



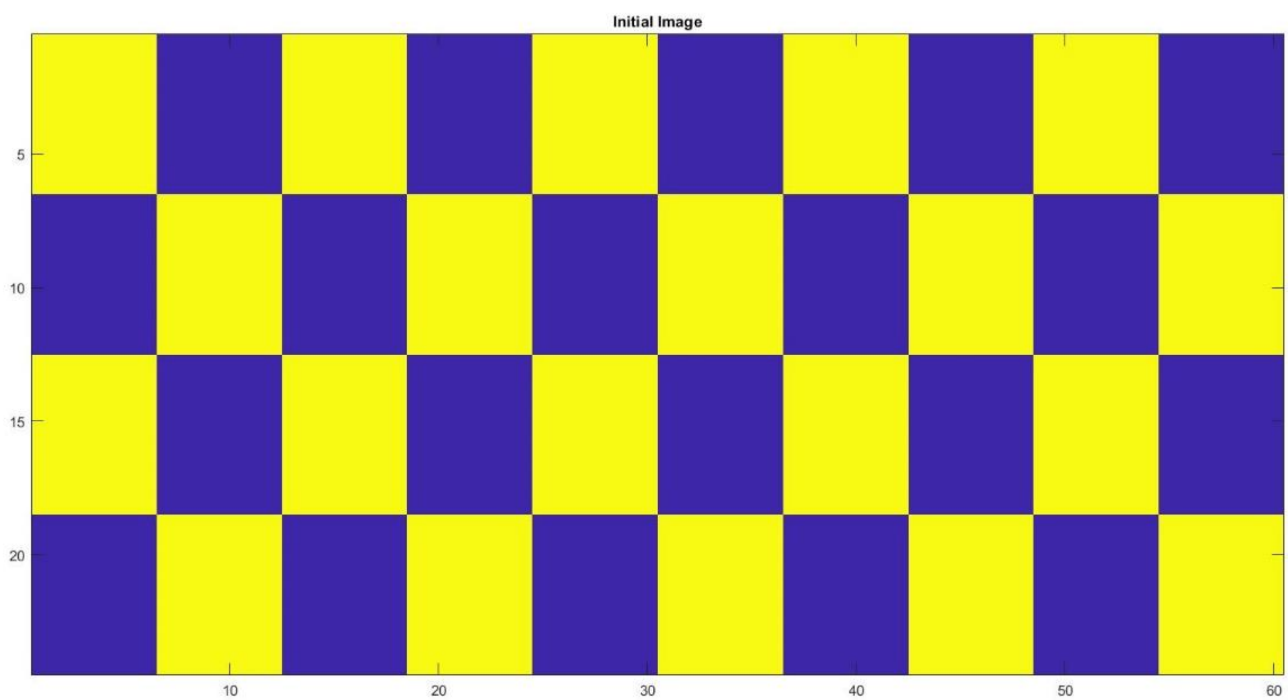
Horizontal lines with high frequency



Chequerboard with high frequency



Chequerboard with low frequency



The components visible in the spectrum correspond to the color's distribution in the initial images. For the first image we may see the vertical distribution of the frequencies in the spectrum since the lines of the initial image change from top to bottom. We may observe there the spatial frequency, which determines the frequency of occurrence of the color across the image with repeated pattern. The highest value (zero frequency) is represented by the central yellow square, which has other neighboring frequency near, indicated by the less bright squares.

Which frequency has a dominating magnitude? Which component

of the image it represents.

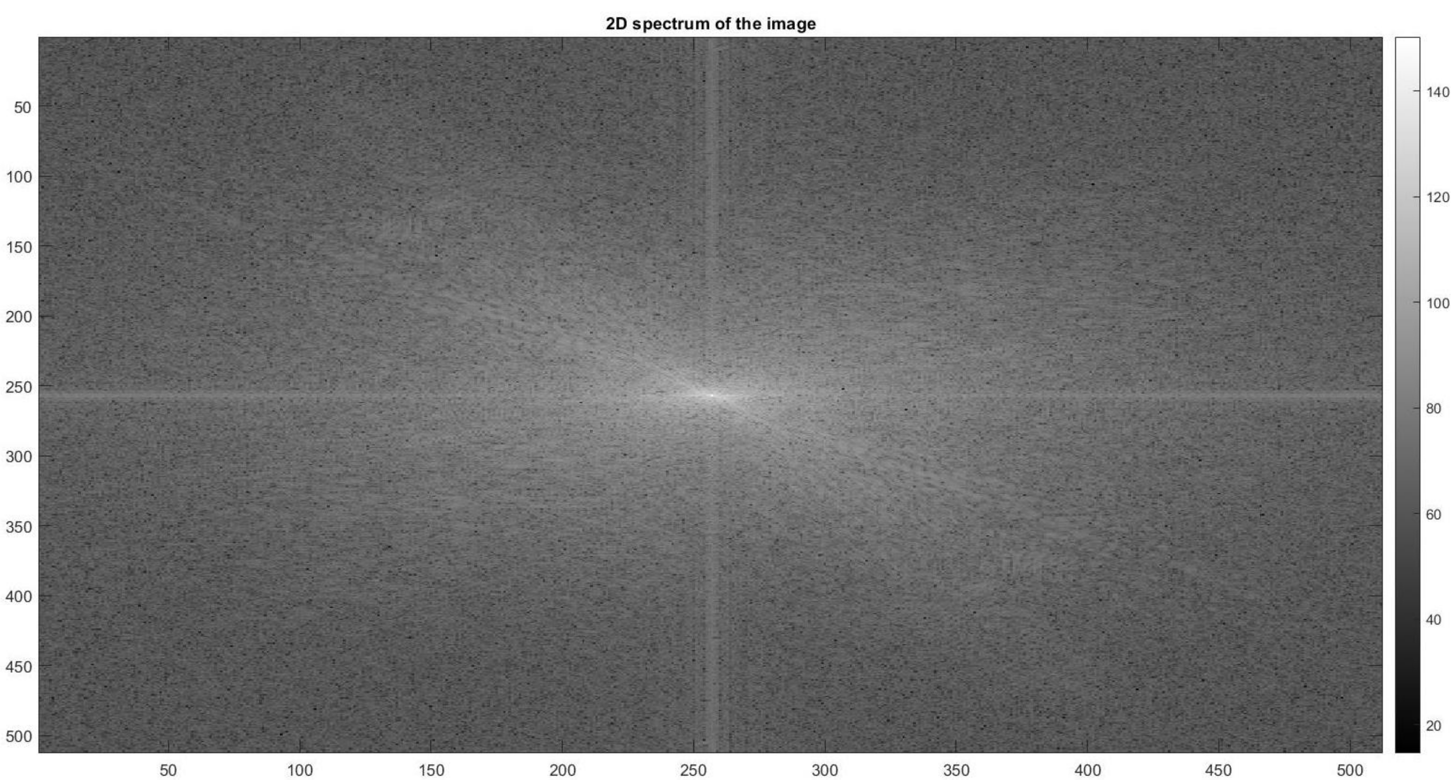
The image reveals the presence of vertical lines with high intensity, indicating that the image possesses a significant amount of high-frequency information in the vertical direction. Conversely, it exhibits low-frequency content in the horizontal direction.

Describe major difference between spectrum of a live image and spectra of Fig. 6.1 – Fig. 6.4

In the chequerboard image, we can observe the presence of high-intensity dots precisely at the corners of the squares. This observation suggests that the image contains frequency content in both the horizontal and vertical axes.

The notable distinction between the two images lies in the orientation of the high-frequency content. In the Lines image, the high-frequency content is primarily concentrated in the vertical direction, whereas in the chequerboard image, it is present in both the horizontal and vertical directions.

Testing a live image



As it can be noticed, the spectrum of the live image doesn't have strictly defined blocks (squares), which correspond to the color frequencies, Instead, we have multiple components present, equally spread around the area. There are some errors present due to the FFT conversion, because of them we may notice those lines (vertical, horizontal, and diagonal). Overall, the spectrum of the live image represents many different components, which are distributed around the central zero frequency element.

Task 6.2.2 Two-dimensional filtering

I used table 9 of the coefficients.

Here is the initial image:

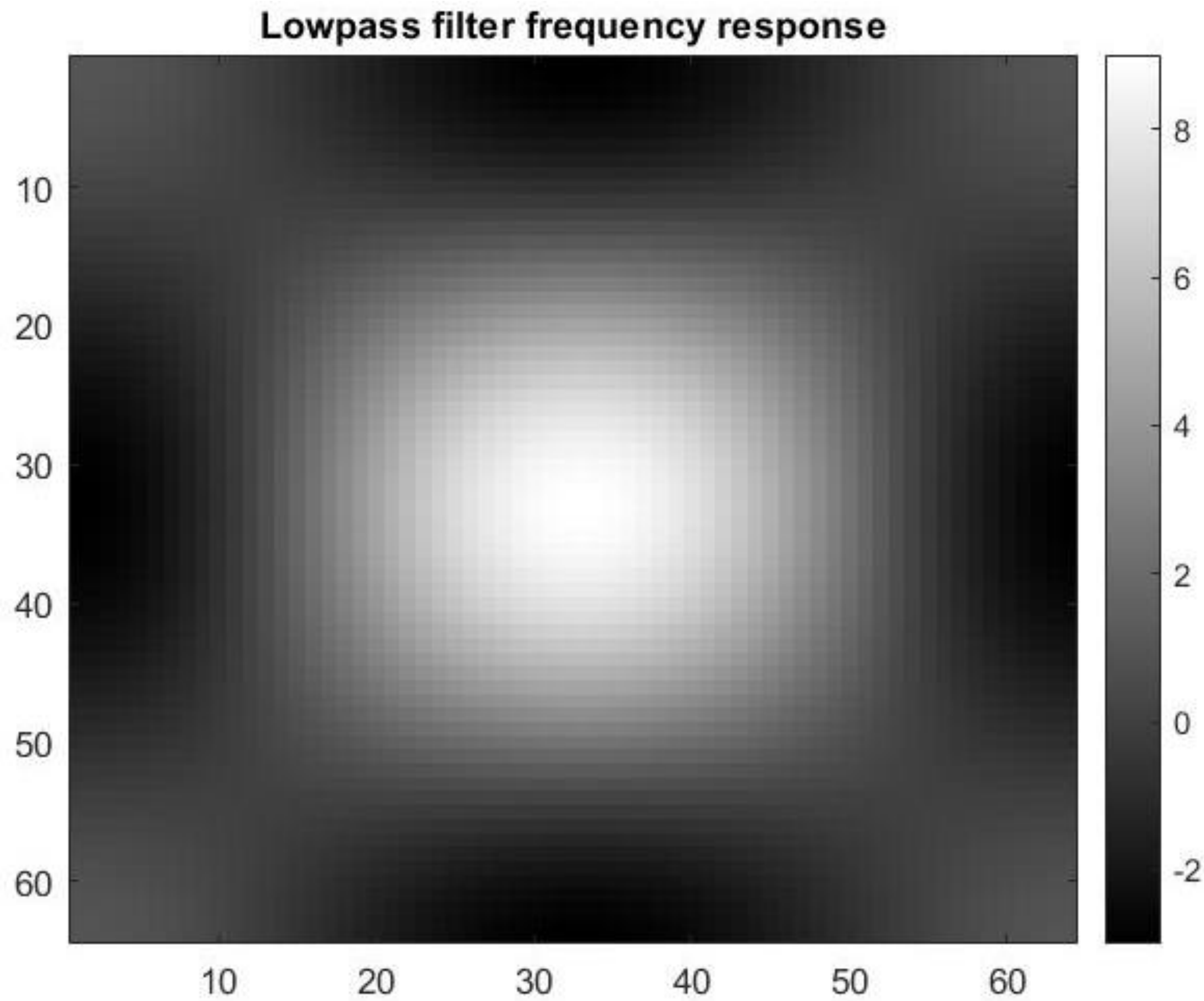
Lowpass filter

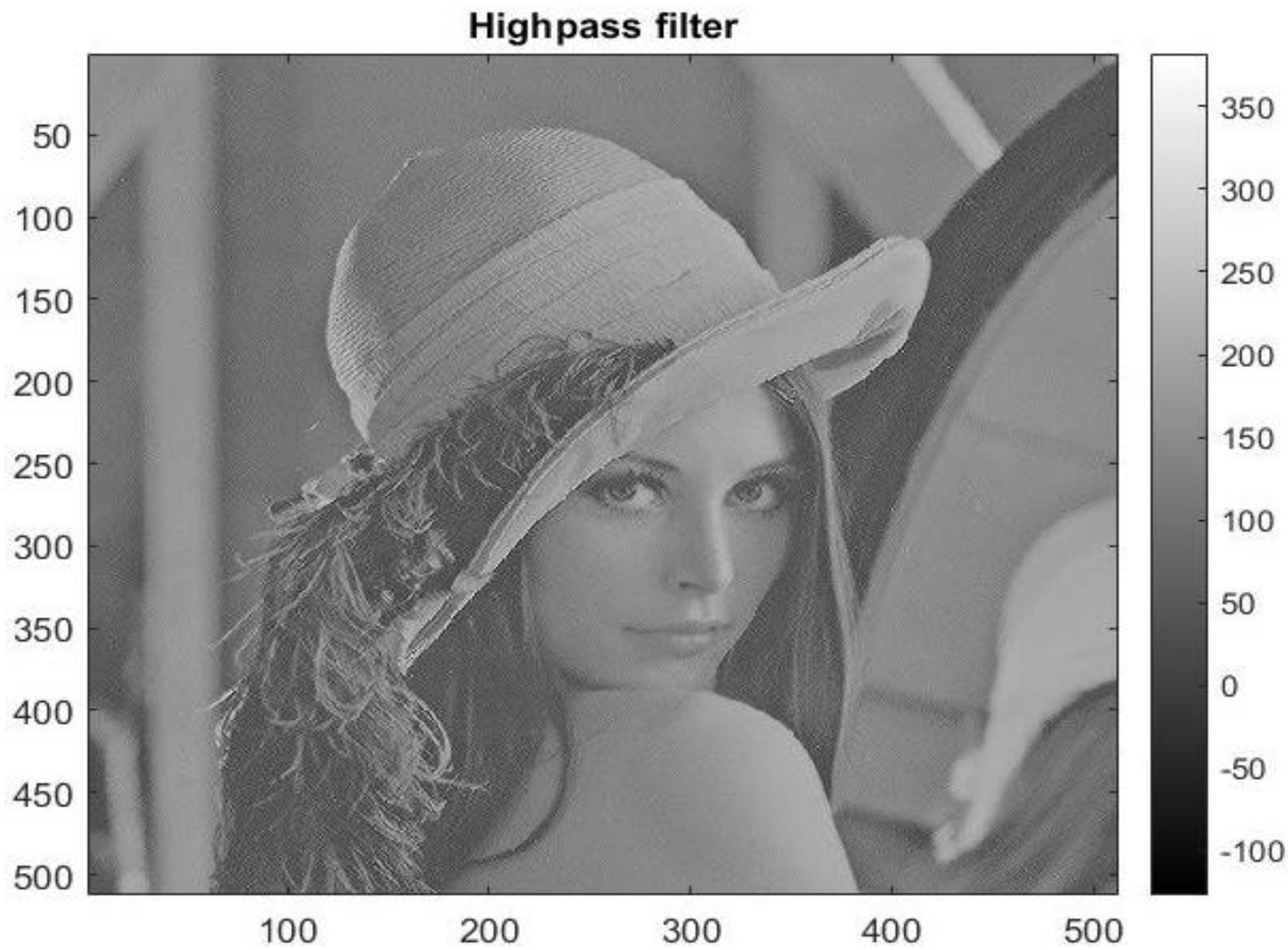
lp1= [1, 1, 1;...

1, 1, 1;...

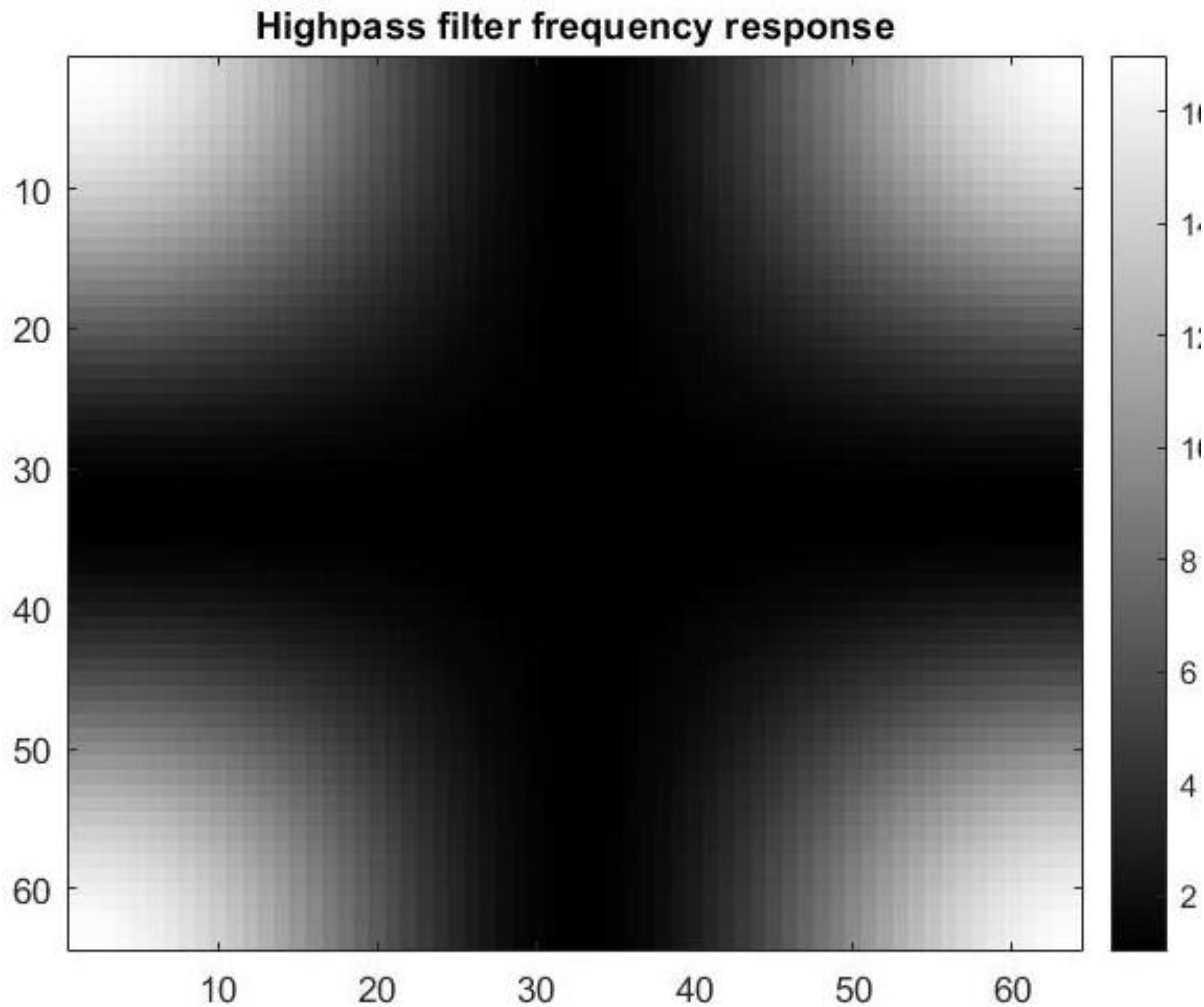
1, 1, 1];e

The image obtained after passing through the Low-pass filter is blurred and softened compared to the initial one.


Lowpass filter frequency response
10
20
30
40
50
60
10
20
30
40
50
60
8
6
4
2
0
-2



The image looks sharper than the initial one, now it is too light, the color depth is lost.



As we can see, the High-pass filter frequency response has quite a different structure compared to the Low-pass filter frequency response.

Question: Describe the filtering effects in two ways: using the term "horizontal/vertical frequency"

Horizontal/vertical frequency" refers to the distribution of image information along the horizontal and vertical axes. A filter that emphasizes horizontal frequencies will amplify the horizontal details in an image, while a filter that emphasizes vertical frequencies will amplify the vertical details.

Question: summarizing the visual effects.

In terms of visual effects, a filter that emphasizes horizontal frequencies will make an image appear wider, while a filter that emphasizes vertical frequencies will make an image appear taller. Conversely, a filter that de-emphasizes horizontal frequencies will make an image appear narrower, and a filter that de-emphasizes vertical frequencies will make an image appear shorter.

6.2.3. Edge detection – mini project

6.2.4. De-noising an image

There exist multiple types of filters that can eliminate additive noise from an image, including Gaussian, Median, and mean filters.

A Gaussian filter functions as a low-pass filter, aiming to blur an image and diminish the visibility of noise. It accomplishes this by convolving the image with a Gaussian function, which assigns more weight to pixels closer to the center of the filter compared to those on the edges. This technique proves effective in eliminating additive noise as it blurs out minor fluctuations in pixel intensity caused by the noise.

On the other hand, a median filter is a non-linear filter employed to eliminate noise from an image by substituting each pixel with the median value of its surrounding pixels. This approach effectively eliminates additive noise by replacing extreme pixel values, caused by the noise, with more moderate values.

Similarly, a mean filter is a linear filter utilized to remove noise from an image by substituting each pixel with the mean value of its neighboring pixels. This method proves effective in reducing additive noise as it replaces extreme pixel values caused by the noise with more moderate values, albeit through a different mechanism than the median filter.

In summary, the Median filter tends to be more effective in eliminating additive noise compared to the mean or Gaussian filter. This is because it avoids substituting a pixel with a value that could potentially be influenced by an outlier.

When it comes to multiplicative noise removal, the Wiener filter is typically regarded as the most efficient filter. This is due to its classification as an optimal linear filter, specially designed to minimize the mean square error between the original signal and the filtered signal in the presence of both additive and multiplicative noise. The Wiener filter leverages the statistical properties of the signal and noise to estimate optimal filter coefficients, resulting in a filter that effectively removes the noise while preserving the integrity of the original signal.