Programming Assignment 2

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Problem 1

Filter 1 – This filter is a weighted averaging filter.

Original Image

Filtered Image

Figure 1: Convolution with Filter 1

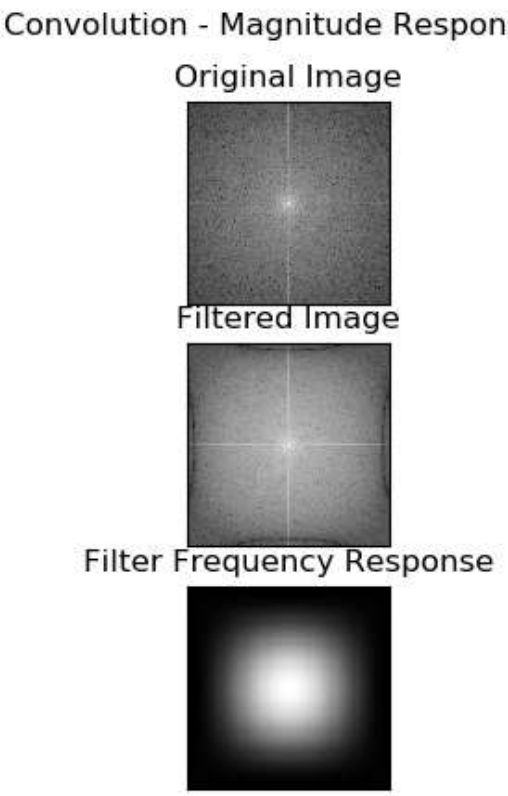


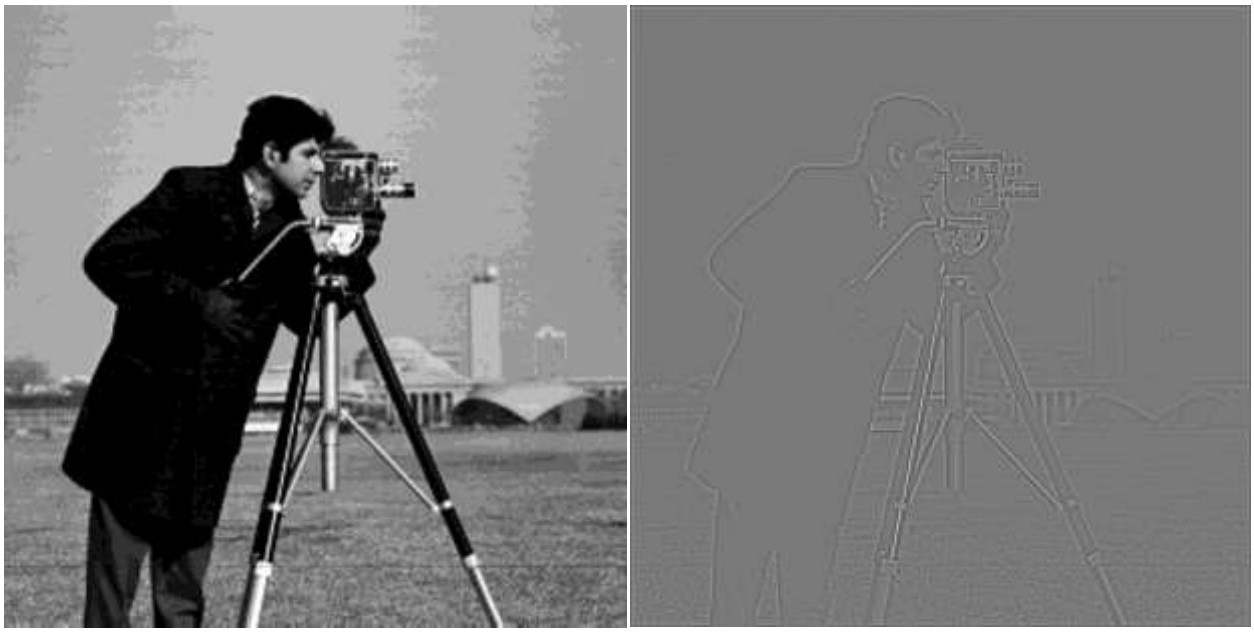
Figure 2: Magnitude and Frequency Response for Filter 1

In Fig. 1, we can see the filtered image has slight blur compared to the original images. The sharpness of the texture of fruits are less prominent. The averaging filter is known to blur the image but maintain the edges. This can be seen in the Fig. 1.

In Fig. 2, we can the magnitude spectrum of the original and filtered image. The original image has a prominent vertical line through the center and a muted horizontal line. This indicates many horizontal edges in the image. There are less number of vertical edges. The original image also has numerous dark gray spots throughout the image. This indicates many frequency changes throughout the image which is because of the texture on the fruits. In the filtered image the horizontal and vertical line through the center has become more prominent. Also, we can see the numerous gray spots have reduced intensities and some have disappeared. This shows that the averaging filter has blurred out the textures on the fruits while maintaining the prominent edges.

In Fig. 2, the frequency response of the filter clearly shows a low pass filter. The higher frequencies are removed which means most of small changes in the image is removed. Therefore the texture of the fruits are smoother in the filtered image.

Filter 2 – This filter is an edge detector



Original Image Filtered Image

Figure 3: Convolution with Filter 2

In Fig. 3, the Original Image and the Filtered Image with the edge detector is shown. The prominent edges in the image can be clearly seen in the filtered image.

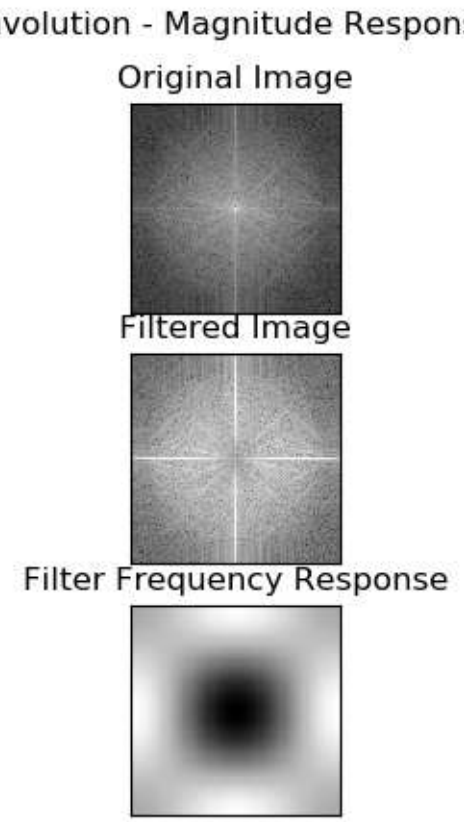
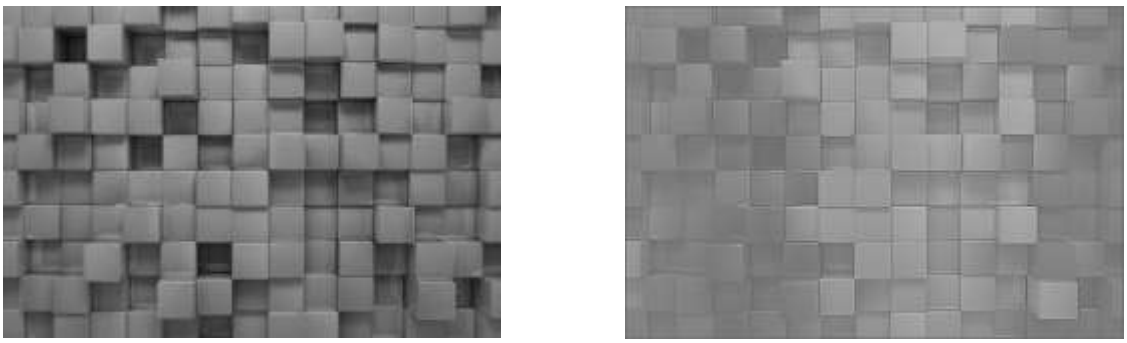


Figure 4: Magnitude and Frequency Response for Filter 2

In Fig. 4, we can see the Magnitude spectrum of the Original Image. The Magnitude spectrum contains multiple straight line passing through the center. This indicates multiple horizontal, vertical and diagonal lines in the image. In the Filtered image magnitude spectrum, we can see the horizontal and vertical lines are more prominent. This indicates that the edges are more prominent in the filtered image. We can also see that the complete magnitude spectrum is at a lighter color. This indicates, there are less sudden changes through out the images except for the edges. The frequency response of the image shows us that this filter is a high pass filter. The center is dark which means the lower frequencies are removed and the higher frequencies are allowed. Hence, the edges are present in the filtered image and the rest is gray.

Filter 3 – This is a sharpening filter.



Original Image Filtered Image

Figure 5: Convolution with Filter 3

In Fig. 5, we can see the original image and the filtered image after applying the sharpening filter. In the filtered image, we can see the edges between the cubes in the image are slightly more emphasized.

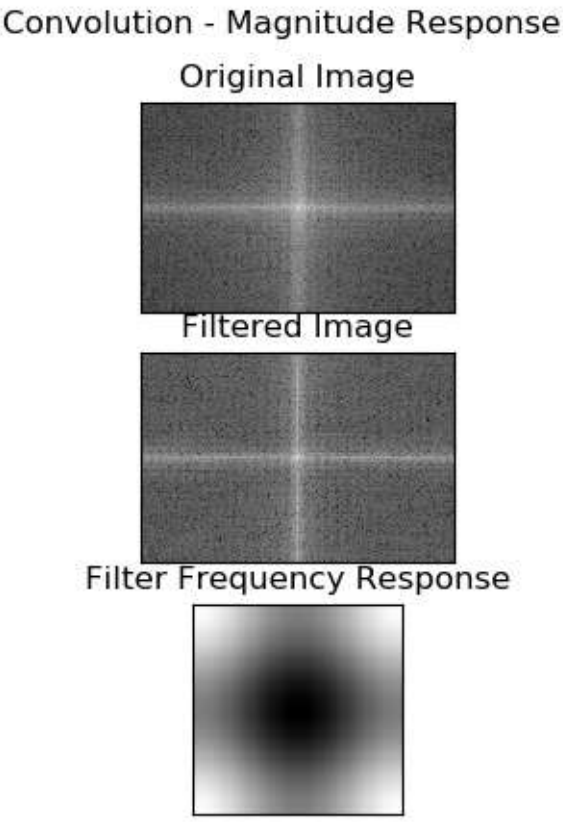


Figure 6: Magnitude and Frequency Response

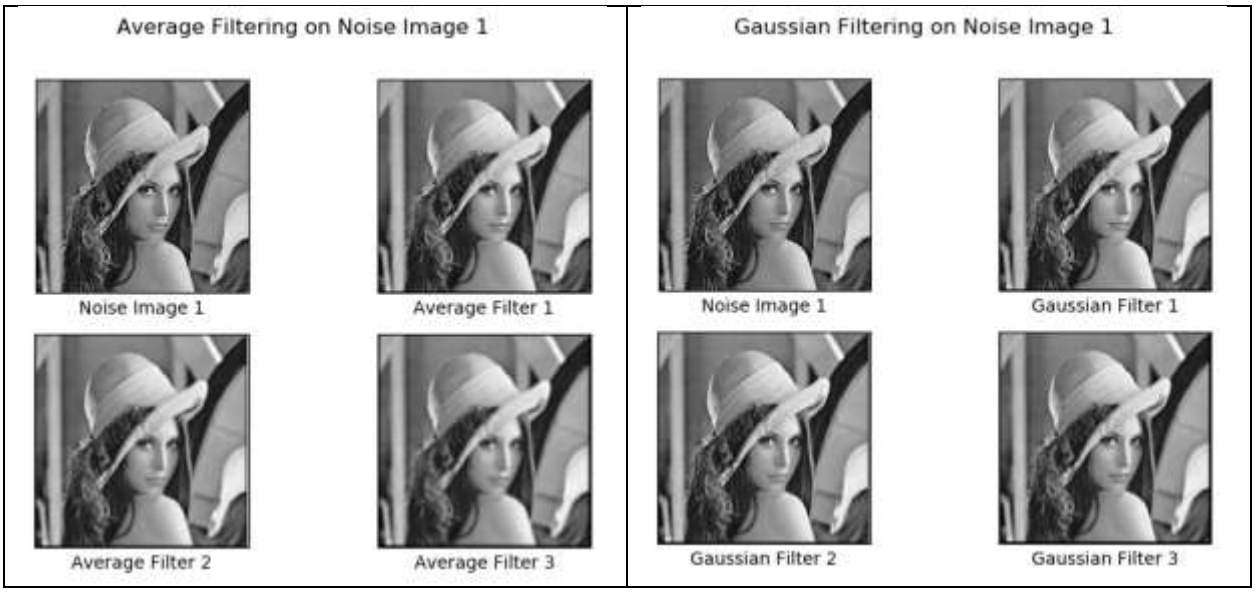
In Fig. 6, we can see the thick horizontal and vertical line passing through the center in the Original Image Magnitude Response. This means, there are many horizontal and vertical lines in the original image. The thickness of the lines indicates that, not all lines are perfectly horizontal and vertical. They are very close to it. In the Filtered Image Magnitude Response, the horizontal and vertical line in the center is more prominent. This means the respective line in the filtered image are emphasized. We can see that the over all magnitude response of filtered image is very similar to original image except for the lines at the center. This could mean the image is not modified much except for sharpening of the horizontal and vertical edges.

In Fig. 6, the frequency response of the filter is shown. The frequency response clearly indicates that the filter is a high pass filter. The lower frequencies are attenuated. Therefore, the filtered image is Fig. 5, is grayer compared to the original image. This means, the dynamic range is lower. Since this is a high pass filter, the edges in the image are emphasized.

Problem 2

Original Image

Noise Level 1 (sigma = 0.01):



Noise Level 2 (sigma = 0.1):

The above figure shows the original image, two noisy images and 3 average filters and 3 gaussian filters applied to both images. We can that the Noise level 1 is not very prominent in the image. It was easily removed by the Average Filter of size 5x5 and the Gaussian filter of size 5x5. We can however see that, the images is bit more blurry when using the average filter for noise removal. The Gaussian filter removes the noise but still maintains some of the features of the image.

When we look at Noise level 2 images, we can see that the noise is very prominent. We can see that, larger the sigma value, more is the noise on the image. This noise was eliminated by the Average Filter of size 7x7, but at the cost of loss of some of the features in the image. The Average filter of size 9x9 made the image too smooth which is not the desired output. On close observation, we can see that the Gaussian Filter of size 9x9 was able to remove the noise from the image. The resultant image is clearer than the output of the Average Filter after noise removal.

From the above two scenarios, we can observe that the Gaussian Filter is more capable of removal of noise while maintaining the image features.