UNIVERSITÀ DEGLI STUDI DI GENOVA

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DEPARTMENT OF COMPUTER SCIENCE AND TECHNOLOGY,
BIOENGINEERING, ROBOTICS AND SYSTEM ENGINEERING

COMPUTER VISION

# Lab 2
## Image filtering and Fourier transform

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# Abstract

The examination of the design and implementation of various image filters is the focus of this assignment. Three primary filters are employed for this purpose: median, low-pass Gaussian, and moving average. Images with various forms of noise are subjected to the filters. The performance efficacy of each image filter in reducing the noise of each image is evaluated by introducing Gaussian and Salt & Pepper noises to the images. Diverse filter diameters are developed to identify the most effective filter. Following this, a variety of linear filters are generated and applied to each image to observe their impact on the image. Lastly, the Fourier transform of the images is computed, and the log magnitude graphs of the image and filters are displayed to determine the information that the Fourier transform of an image or filter provides.

# 1 Adding Noise

This section involves the addition of various noises to the image, followed by the development of filters and their application to the noisy image in order to evaluate its performance. In order to accompany the presentation of this report, one of the images has been selected. The image in question has been subjected to the application of Gaussian noise with a standard deviation of twenty, as well as salt and pepper noise with a density of twenty percent. It is possible to view the original image as well as the photos with various noises, along with their respective histograms, displayed in Figure 1. It is necessary to define two distinct local functions in MATLAB for the purpose of adding these noises to the images. These functions are for Gaussian noise and Salt-Pepper noise, respectively. After that, these routines can be invoked in order to introduce noise into the photos. Taking into consideration the images that are displayed together with their histograms in Figure 1, it is clear that the photos have undergone significant transformations and appear to be quite noisy. An appropriate filter ought to be developed in order to eliminate these disturbances while yet preserving the necessary features of the photos.

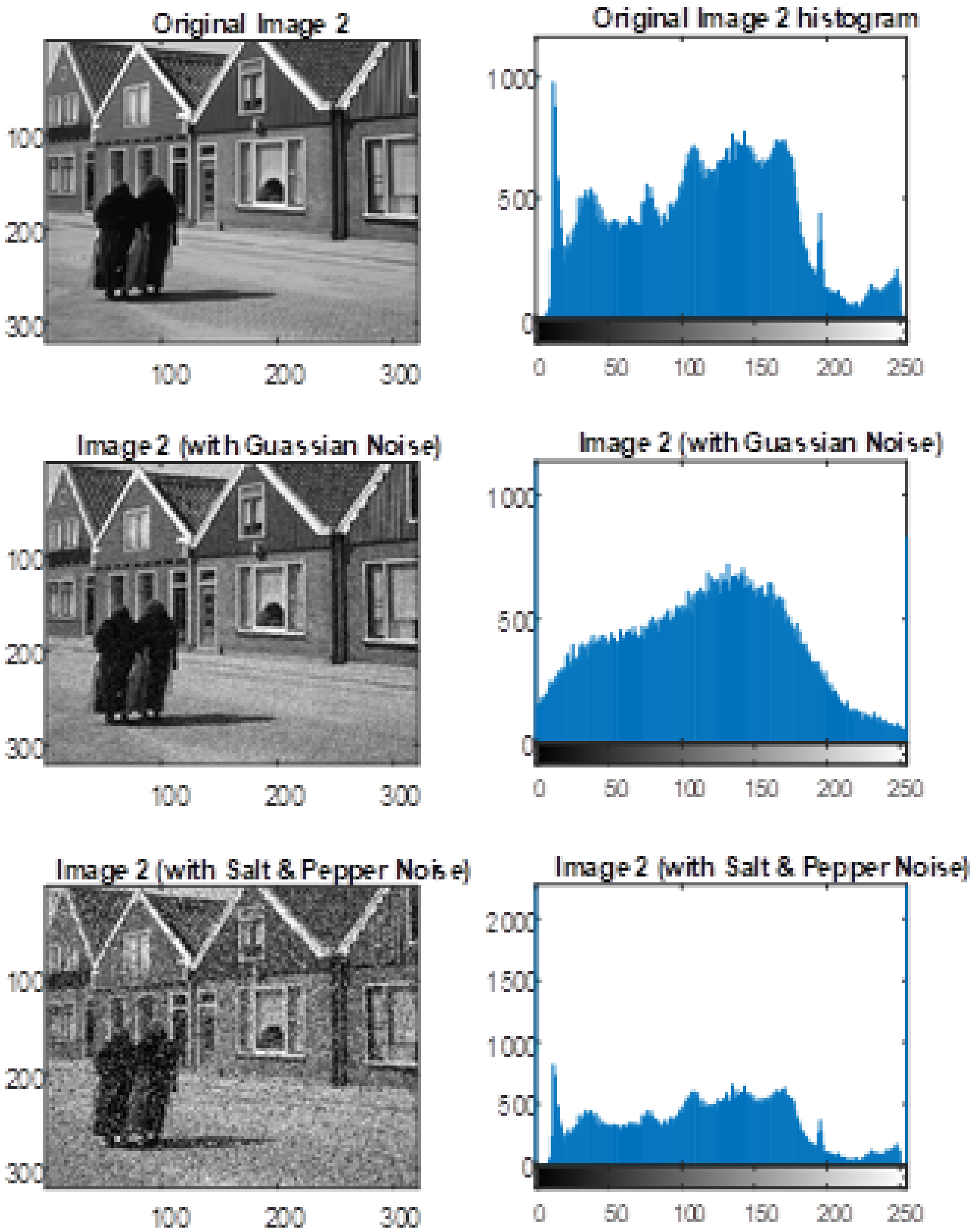



Figure 1: Original Image, Image with Gaussian noise, and Image with Salt & pepper noise and their histograms

## 2 Applying different filters to the image

Three distinct filters, namely the moving average filter, the low-pass Gaussian filter, and the median filter, have been developed specifically for application to the images. Initially, the moving average filter is conceived of and developed. Three-by-three and seven-by-seven pixel filters are built in order to evaluate the impact of the moving average filter size. Figure 2 illustrates the form of the 7*7 filter that is being processed.

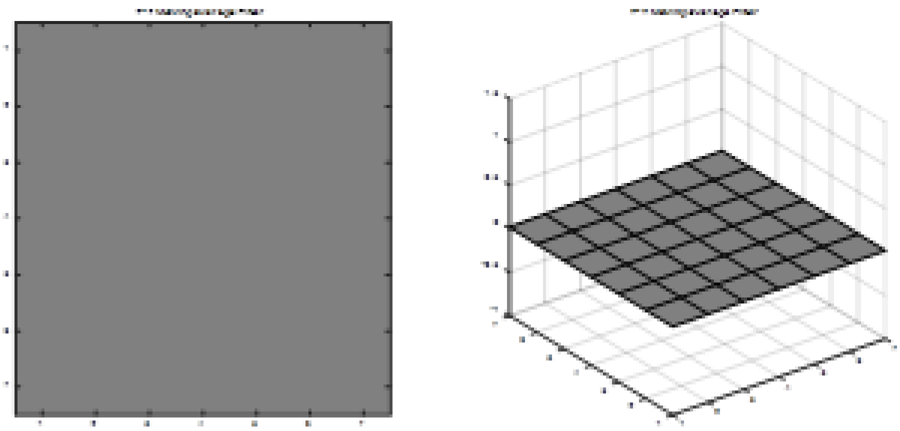


Figure 2: Moving average filter with 7*7 pixels

Following the application of these two moving average filters to the image that contains Gaussian noise, it is possible to observe, on the basis of the plots presented in Figure 3, that the 3*3 pixels filter eliminates a portion of the noise associated with the image. It should be noted, however, that the image still contains a significant amount of noise. There is a significant reduction in the amount of noise in the picture when the size of the filter is increased to 7 by 7. Unfortunately, some of the picture's features are lost, and the picture itself gets hazy, which is not something that is desirable for some tasks. In this section, a function is built to plot the figures in order to reduce the amount of code that is currently being composed. In order to draw the plot of the image and its histogram, this function obtains the name of the image, the name of the noise, the name of the filter, and the size of the filter. Salt and pepper noise is next applied to the image, and then the moving average filters are applied to the image. It is clear from the findings presented in Figure 4 that the moving average filters are not effective in removing the salt and pepper noise from the data. There is not much of an impact that the image filter with 3*3 pixels has on the picture because the picture is still entirely noisy throughout. On the other hand, the picture becomes indistinct when the 7*7 pixels moving average filter is applied there. It should be brought to your attention that even when the 7*7 filter is utilized, a significant amount of noise can still be observed.

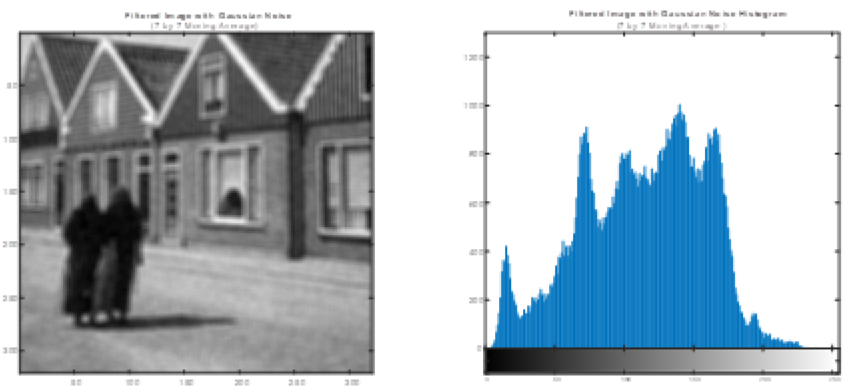


Figure 3: Image with Gaussian noise filter by a moving average filter with 7*7 pixels

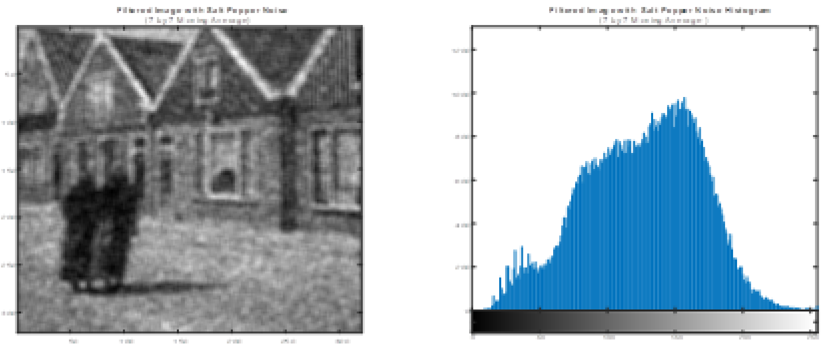


Figure 4: Image with Salt & Pepper noise filter by moving average filter with 7*7 pixels

As a result of the fact that low-pass Gaussian filters give greater weight to the central pixel as opposed to giving the same weight to all of the neighborhood pixels, it is anticipated that these filters will demonstrate a higher level of accuracy in contrast to moving average filters. The creation of low-pass Gaussian filters with 3*3 and 7*7 pixels is demonstrated in Figure 5, with the 7*7 filter being the one that is most visible.

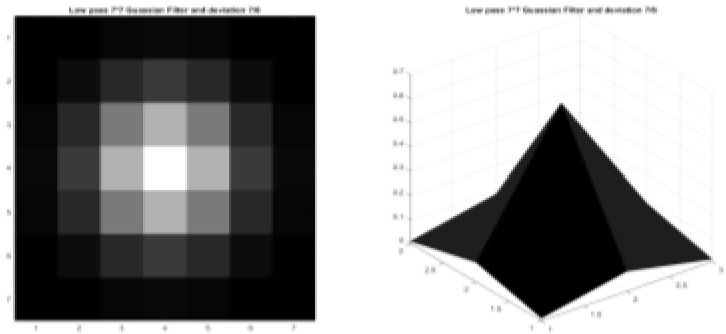


Figure 5: Low pass Gaussian filter with 7*7 pixel size

The use of both 3*3 and 7*7 low pass Gaussian filters on the image that contains Gaussian noise reveals, as shown in Figure 6, that this filter has been successful in reducing the noise to a level that is acceptable. When compared to the moving average filter of the same size, the 7*7 filter is able to totally eliminate the majority of the noise, and despite the fact that the picture becomes slightly blurry, it is still able to display the correct features of the image. When applying the low-pass Gaussian filters that were constructed to the image that had Salt & Pepper noise, the identical difficulty and problem that the moving average filter presented is encountered. To obtain a new value for that filter, it takes the value of the central pixel and the values of some nearby pixels and adds them together. This is based on the concept of the Gaussian filter. Within the context of this summing, however, it gives the central pixel a greater weight. This approach is not capable of effectively removing this type of noise because the salt and pepper noise adds some pixels to the image that are entirely white and black. These pixels will continue to be there even after the filter has been applied, regardless of whether or not the filter size is increased. In spite of the fact that the size was increased, it is evident from Figure 7 that the noise is still present, and the picture also loses some of its details.

After everything is said and done, two median filters with pixel widths of 3*3 and 7*7 are constructed and applied to images that contain Gaussian noise as well as Salt & pepper noise. These filters are displayed in Figure 8 and Figure 9, respectively. When it comes to removing salt and pepper noise, this particular type of filter performs far better than the moving average and Gaussian filters, as demonstrated in Figure 9. In comparison to the values of the pixels that are adjacent to it, median filters select the pixel value that has the median intensity. Both the intensity of the salt and pepper noise pixels is either too high or too small. As a consequence of this, the noise pixels are regarded as outliers on the basis of their intensity value, and a final image that is appropriately composed is produced. The one and only issue with this is that it does not take into account the minute elements of the photo, such as the thin and small lines that are on the walls. This may be owing to the fact that the intensity value of these lines may be considered to be outliers and noise in this particular instance. It is possible that increasing the size of this filter will result in the loss of further minute details, leaving just the primary details of the picture, such as the shape of the houses and the borders of the people to be preserved.

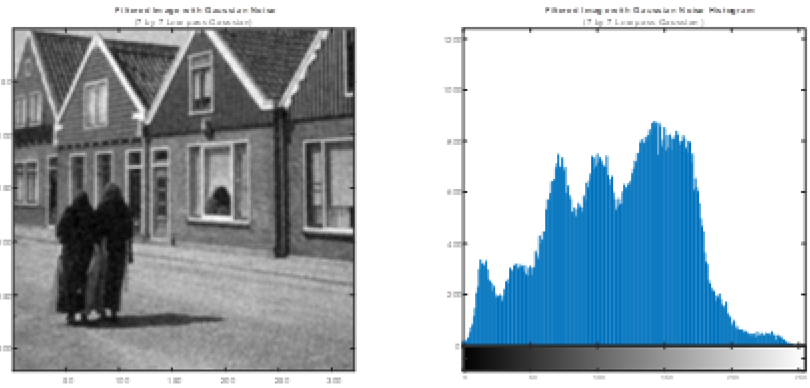
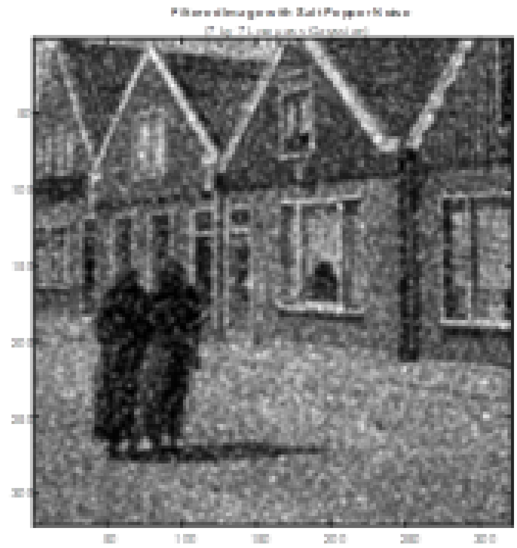


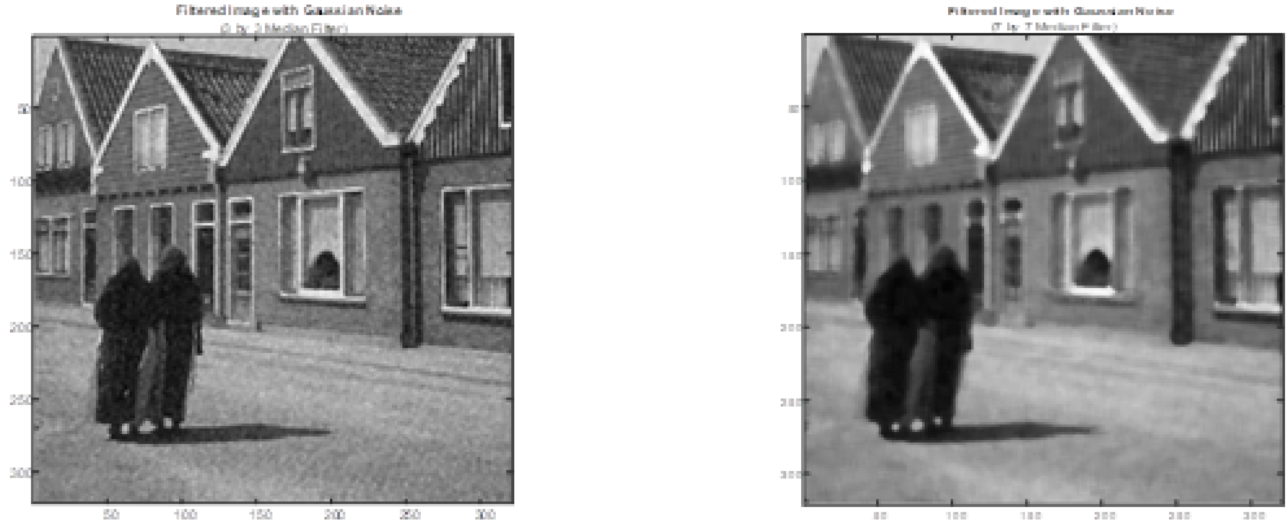
Figure 6: Image with Gaussian noise filtered by low-pass Gaussian filter with 7*7 pixels

(a)



(b)

Figure 7: Image with Salt & Pepper noise filtered by low-pass Gaussian filter with (a) 3*3, and (b) 7*7 pixels




(a) (b)

Figure 8: Image with Gaussian noise filtered by Median filter with (a) 3*3, and (b) 7*7 pixels

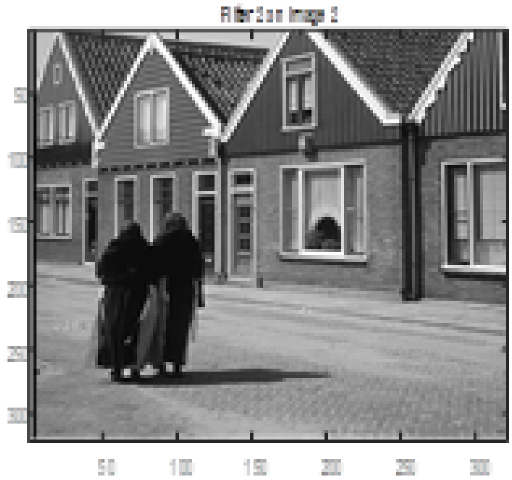

(a) (b)

Figure 9: Image with Salt & pepper noise filtered by Median filter with (a) 3*3, and (b) 7*7 pixels

## 3 Practice with linear filters

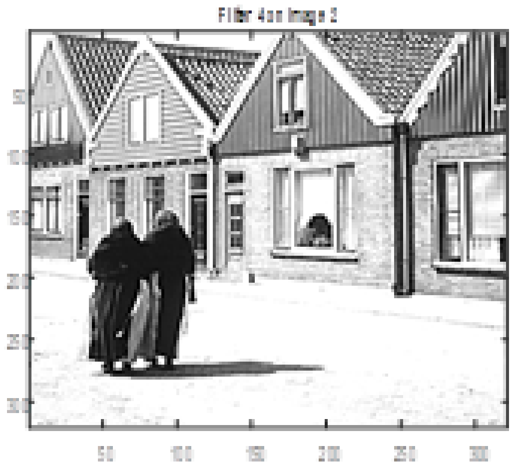
As part of this segment, a variety of linear filters are applied to the image in order to see the effects that each filter has on the picture. It is clear from looking at Figure 10 that the first filter does not alter the image in any way because it merely adds the intensity of the central pixel and gives the neighboring pixels no weight at all. When we talk about the filters in image (b), we are referring to those filters that alter the position of the image and shift it in either the horizontal or vertical direction. The value of the central pixel is changed to the value of a nearby filter when this filter is applied. Image (c) and image (d) demonstrate the effect that a sharpening filter has on an image. It is possible to improve the edges and certain details in a picture by using a sharpening filter, which is also often known as an edge-enhancement filter. This filter is used to make the edges and details appear more prominent. Sometimes it is used to improve the quality of a picture in some way by increasing the contrast at the boundaries of regions of differing pixel intensity values. This is usually done in order to improve the overall image quality. By using this filter, dark sections will appear darker, while light regions will appear lighter at the edges of the image. Because an excessive amount of sharpening (image (d) of Figure 10) can cause an image to appear unnatural and can result in the loss of certain critical information, it is essential to apply sharpening filters in the correct manner during the editing process.


(a)



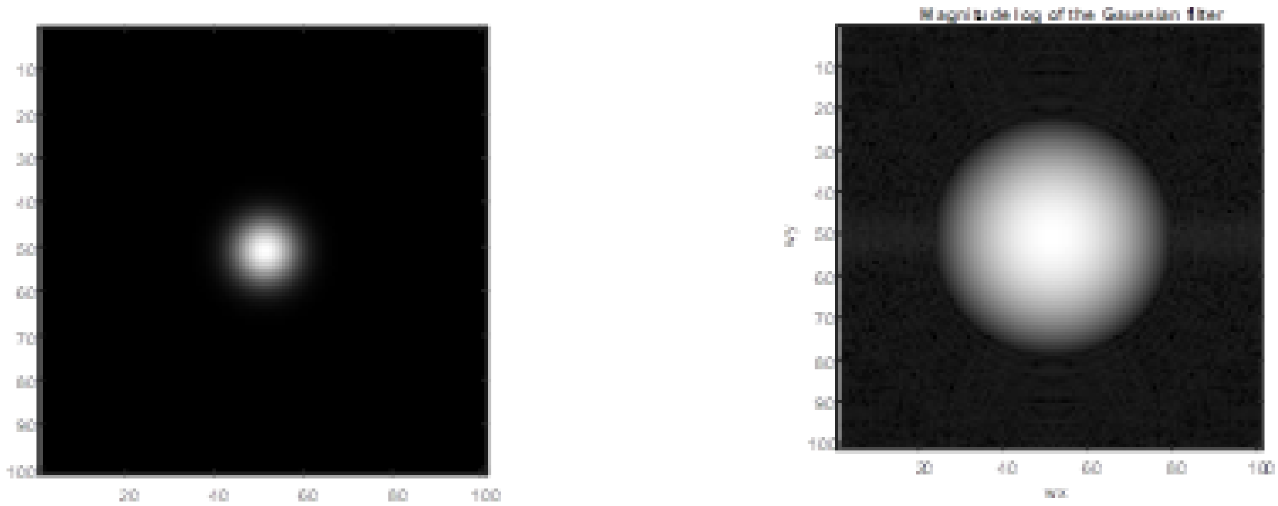

(b)


(c)




(d)

Figure 10: Using different linear filters on images




(a) (b)

Figure 11: Low-pass Gaussian filter image and magnitude log of the Fourier transform

# 4 Applying the Fourier transform on the image

For the purpose of determining the appearance of the magnitude (log) of the modified image, the Fourier transform, the low-pass Gaussian filter, and the sharpening filter are all applied to the image in this section. Given the information presented in Figure 11, it is possible to make the observation that the Fourier transform of a low pass Gaussian filter results in a Gaussian filter that has a bigger standard deviation.

## 5 Conclusion

For the purpose of this project, a number of distinct kinds of noises were applied to an image. After that, various kinds of filters were applied to each noisy image in order to evaluate how well the filter handled the process of removing the noise. In a nutshell, the specifications of the image processing task should be taken into consideration when selecting the appropriate filter. It is possible for moving averages to blur details and edges, despite their simplicity and efficiency. The use of Gaussian filters provides an excellent compromise between the reduction of noise and the preservation of detail. When it comes to reducing impulse noise, median filters are fantastic; however, they might not be as effective when dealing with Gaussian noise. When it comes to image processing, it is usual practice to employ a variety of filters in order to produce the desired results.