Laboratory Session 2

Computer Vision - Università Degli Studi di Genova

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***Abstract*—A variety of image filters were implemented to images with different types of noise with the objective of studying the different effects that the filtered images can get by changing the characteristics of the filters used.**

***Index Terms*—image filtering, fourier transform, linear filtering, median filter**

I. Introduction

In this lab ([2]) some basic image noise-filtering operations are to be implemented using Matlab. Gaussian and salt pepper noise will be added to the two source greyscale images displayed in Fig.1 and Fig.2 and then, a moving average, a low-pass Gaussian and a median filter with different spatial support are applied to filter the noisy images. Other linear filters will be applied on the source images to see what effects can be applied to them and how they can potentially be enhanced. Finally, a Fourier Transform will be applied to the source images and filters to evaluate their characteristics in the frequency domain.

Fig. 1. Test Image of a tree. Source: [2]

Fig. 2. Test Image of a town. Source: [2]

II. Procedure

A. Task 1

Two different types of noise were added to the images: Gaussian noise and salt and pepper noise. To add Gaussian noise, the intensity of each pixel is changed by a random amount based on Gaussian distribution. To add Salt and Pepper noise, white and black pixels are placed randomly throughout the image.

B. Task 2

Three different filtering techniques were used to remove the noise added in Task 1: a moving average, a low-pass Gaussian filter, and a median filter.

C. Task 3

Four different linear filters were used on the test images: an identity filter which duplicated the image, a shifting filter which shifted the image by one pixel, an averaging filter, and a sharpening filter which involves the convolution of two identity filters subtracted by an averaging filter.

D. Task 4

The Fast Fourier Transform was used to display the magnitude of the transformed images, the transformed low pass Gaussian filter and the magnitude of the sharpening filter.

III. Results and Analysis

A total of 98 images were obtained after running the Lab2.m script in the MATLAB workspace as follows:

Lab2();

The following images and analysis shown are the most useful ones for understanding the effect of each task from the procedure. However, the reader can access the full set of images in the folder called "plots", automatically generated when the script is executed.

A. Task 1

Fig. 3 and Fig. 4 are examples of adding the different types of noise to the test images. Only the town image is shown for brevity. Notice that the difference between the type of noise added is visible, the Fig. 3 shows a more statistically random noise in contrast to the Fig.4 that only has black and white pixels randomly added.

Fig. 3. Town with Gaussian noise. Source: Own elaboration

Fig. 4. Town with salt and pepper noise. Source: Own elaboration

B. Task 2

In Fig. 5 the town image with Gaussian noise has it removed by using a 3x3 average filter while Fig. 6 uses a 7x7 filter instead. It can be seen that the average filter accentuates the features of the image despising the noise added. Also, it is evident that using the larger filter results in a more blurred image, that means less noticeable noise but at the cost of losing raw information of the image. A similar result can be seen when removing salt and pepper noise by comparing Fig. 7 and Fig. 8.

Fig. 5. Town with Gaussian noise and 3x3 average filter. Source: Own elaboration

Fig. 6. Town with Gaussian noise and 7x7 average filter. Source: Own elaboration

In the Fig. 7 it can be seen that the Gauss filter isn't the best way to filter an image affected by salt and pepper; in contrast to the Fig. 8, where it is noticeable that the median filter is very

effective against salt and pepper noise. That is because with the median filter is highly probable that the pixels affected by the noise won't be the median of the spatial support, resulting in an image without salt and pepper noise. However, it can also be noticed that even if the image not longer has a visible effect of the noise, the filter causes some raw information to be lost. Also, even if the Gauss filter isn't in this case effective, it can be useful when an image needs to be smoothed to detect fewer and more noticeable edges in an image.

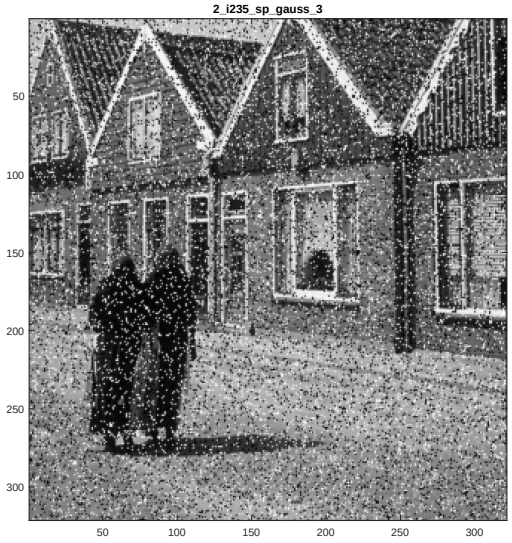

Fig. 7. Town with salt and pepper noise and 3x3 Gauss filter. Source: Own elaboration

Fig. 8. Town with salt and pepper noise and 7x7 median filter. Source: Own elaboration

C. Task 3

Four different filters were created and applied to the test images. All the filters were of size 7x7. Comparing Fig. 9 and Fig. 2, it is clear that these two images are identical. This is good because Fig. 9 is the result of the source image convolved with an identity filter, so there should be no difference.

Fig. 9. Town with a 7x7 identity linear filter. Source: Own elaboration

If a similar comparison is done with Fig. 10, it can be seen that it is the same as the source image but it is shifted to the right by one pixel. This makes sense as a shift filter was convolved with the test image to get this output image.

Fig. 10. Town with a 7x7 shift linear filter. Source: Own elaboration

Looking at Fig. 11, it is merely a blurred version of the source image. This was done by applying a moving average filter to the source image.

Fig. 11. Town with a 7x7 blur linear filter. Source: Own elaboration

Fig. 12 is the most interesting when compared to the source image. It is a sharpened version of the original, which is done by accentuating the differences with a local average. The actual filter and the surf of the filter are shown in Fig. 13 and in Fig. 14

Fig. 12. Town with a 7x7 sharpening linear filter. Source: Own elaboration

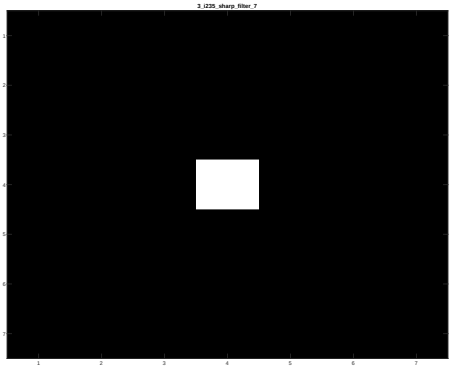

Fig. 13. 7x7 sharpening linear filter. Source: Own elaboration

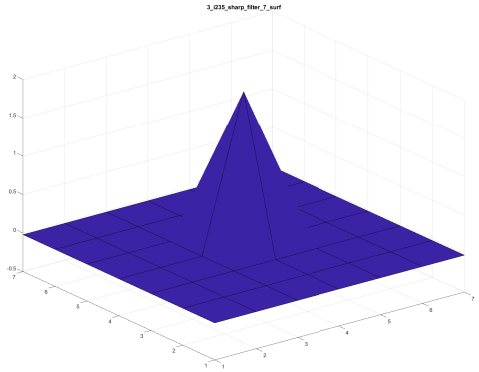

Fig. 14. 7x7 sharpening linear filter displayed with surf. Source: Own elaboration

D. Task 4

In the Fig.15, the magnitude of the Fourier transform of the source image is displayed. Not much can be deduced from this image so that explains why the magnitude of the Fourier transformed image isn't commonly use for image processing.

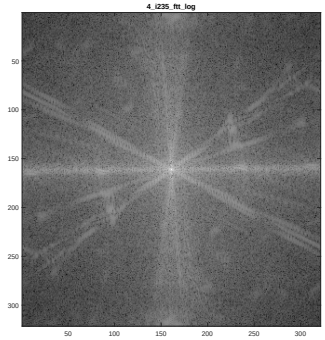

Fig. 15. Magnitude Town. Source: Own elaboration

In the Fig.16, the magnitude of the Fourier transform of a

Gaussian filter is shown, also the blur effect that this kind of filter does to an image can be noticed. Moreover, the diameter of the white circle corresponds to the value of the standard deviation used, which in turns means the amount of blur applied.

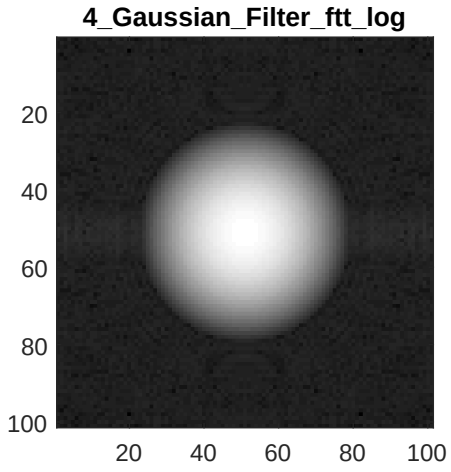

Fig. 16. Magnitude Gaussian filter of sigma equals 5. Source: Own elaboration

In the Fig.17 and Fig.18 the effect of the sharpening filter in the frequency domain can be appreciated. Notice the similarities between those and the ones obtained in the previous task and the perceived effect that the filter has to the image. It can be seen how the functioning of the sharpening filter of accentuating the differences with respect to the local average in the spatial support works in the frequency domain.

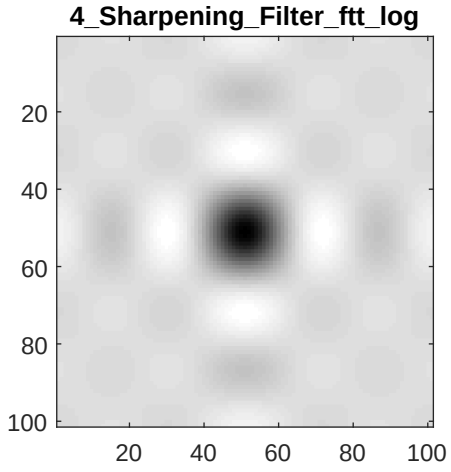

Fig. 17. Magnitude sharpening filter. Source: Own elaboration

IV. Conclusions

- Even if a filter can reduce the effects of noise in an image, it will also always lose raw information of the source image. A study should be performed - in function of the features needed - to decide what type of filter is the most appropriate.
- Some types of filters are more efficient against certain types of noise.
- An analysis in the frequency domain can also be performed in images and filter, increasing the available toolbox of image processing in order to get the best possible image needed.

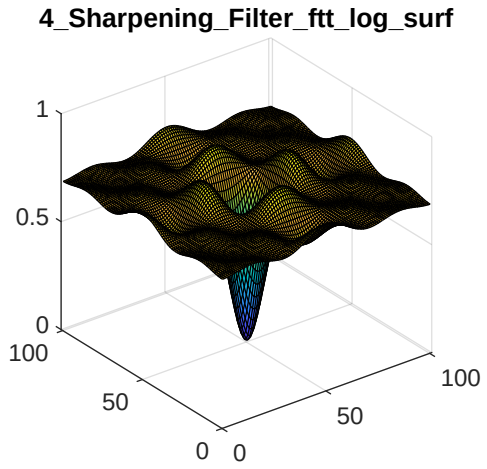

Fig. 18. Fourier transform of the sharpening filter displayed with surf. Source: Own elaboration

References

[1] Solari, F. Part 2 - Image Filtering Fundamentals, 2020. Retrieved from: https://2019.aulaweb.unige.it/pluginfile.php/209249/mod_resource/content/4/lecture2_filtering_fft.pdf

[2] Solari, F. Lab Session n.2, 2020. Retrieved from: https://2019.aulaweb.unige.it/pluginfile.php/209251/mod_resource/content/2/Lab2.pdf