Experiment 2

Mücahit Veli Cumart, 21605893

BBM 415

Fundamentals of Image Processing Lab

Hacettepe University

b21605893@cs.hacettepe.edu.tr

Introduction

Subject of this experiment is Image Filtering in Image Processing. Image Filtering which is important subject in this area has been used different purposes. It is widely used for smoothing the images or edge detection. There are lots of filters for these aims. We learned about a few of these filters like Gaussian Filter,Mean Filter(Averaging Filter),and Kuwahara Filter. In this assignment, we primarily implemented these filter in Python. After the implementation, we used these implementations for different images and different parameters.

Experiment

There are three filters me to have to implement in this experiment. These filters is different from each other. One of these filters is Mean(Averaging) filter which is a method of smoothing images by reducing the amount of intensity variation between neighbouring pixels. The Mean Filter works by moving through the image pixel by pixel, replacing each value with the average value of neighbouring pixels, including itself. Second filter is Gaussian Filter in this experiment. The Gaussian Filter is a 2-dimensional convolution (the operation of multiplying the pixels on the image by the core matrix) filter used to 'blur' images and remove detail and noise. In this sense, it is similar to the mean filter. During the calculation Gaussian filter, the standart deviation is used. It effects the output of the filtered image.Third filter is Kuwahara Filter which is a non-linear smoothing filter for adaptive noise reduction.Most filters that are used for image smoothing are linear low-pass filters that effectively reduce noise but also blur out the edges. Howevver the Kuwahara Filter is able to apply smoothing on the image while preserving the edges.

EXAMPLE 1 – MEAN FILTER

Mean filter is used for smoothing images,and removing the high frequencies which are in the images. When the filter size is changed, the output of the filtered image is changes. We can implement this filter in different sizes like 3x3, 5x5,7x7,9x9,11x11,etc.Because of the calculation of this filter, when the size of the filter is increased, the smoothing of the image increases, and also the blur of the image increases,too.If we change the filter size, the number of neighbors affecting the current pixel changes. The calculation of Mean filter is below.

```
for k in range(-kernelValue, kernelValue + 1):
    for l in range(-kernelValue, kernelValue + 1):
        new_R = new_R + image.getpixel((i + k, j + l))[0]
        new_G = new_G + image.getpixel((i + k, j + l))[1]
        new_B = new_B + image.getpixel((i + k, j + l))[2]
new_R, new_G, new_B = int(new_R / (windowSize ** 2)), int(new_G / (windowSize ** 2)), int(
    new_B / (windowSize ** 2))
image.putpixel((i, j), (new_R, new_G, new_B))
```

Original Image of Example 1

3x3 Mean Filter for Example 1

5x5 Mean Filter for Example 1

7x7 Mean Filter for Example 1

9x9 Mean Filter for Example 1

In this example of Mean Filter, we can see that if the size of filter increases, the smoothing of the image increase. But also, the blur of the image increases. We can say that the image quality is decreasing when we increase the filter size in this example of Mean Filter.

EXAMPLE 1 – GAUSSIAN FILTER

Gaussian Filter is usually used to blur or to reduce noise. In Gaussian Filter, the pixels nearest the center of the kernel are given more weight than those far away from the center. This averaging is done on a channel-by-channel basis, and the average channel values become the new value for the filtered pixel. This filter is similar to weighted mean filter, but it uses a different kernel that represents the shape of a Gaussian hump,and also it is a non-uniform low pass filter. In this filter, the effect of the neighbour pixels on the mean decreases as you move away from the center. When we compare this filter with median filter, Gaussian is more effective than median filter. The formula of creating Gaussian filter with different size is below. Additionally, Gaussian filter has another parameter named Sigma which effects the output of the filtered image. I understand that if the size of the filter is increased, we should increase the sigma value. When sigma value is increased, the output is better than the low sigma.

```python
def GaussianFilter(image, windowSize, sigma):
    rangeVal = int((windowSize - 1) / 2)

    gaussian_mask = np.zeros((windowSize, windowSize))
    for i in range(-rangeVal, rangeVal + 1):
        for j in range(-rangeVal, rangeVal + 1):
            var_x = sigma ** 2 * (2 * np.pi)
            var_y = np.exp(-(i ** 2 + j ** 2) / (2 * sigma ** 2))
            gaussian_mask[i + rangeVal, j + rangeVal] = (1 / var_x) * var_y
```

Original Image of Example 1

3x3(Sigma:1) Gaussian Filter of Example 1

3x3(Sigma:2) Gaussian Filter of Example 1

5x5(Sigma:1) Gaussian Filter of Example 1

5x5(Sigma:2) Gaussian Filter of Example 1

7x7(Sigma:1) Gaussian Filter of Example 1

7x7(Sigma:2) Gaussian Filter of Example 1

9x9(Sigma:1) Gaussian Filter of Example 1

9x9(Sigma:2) Gaussian Filter of Example 1

With this Example of Gaussian Filter, I understand that the filter size and the sigma value are related to each other. The image of this example is same size for all filter sizes and sigmas. When we look at the ‘’3x3 and Sigma:1 ‘’ , we can see that the smoothing is very little. If we increase the sigma from 1 to 2 in this size, the high frequencies decreasing in the image. That’s why the image is darker than when sigma is 1. After this,in the ‘’5x5 and Sigma:1’’ , There is more smoothing from 3x3 sigma:1. When we increased the sigma value in this size from 1 to 2, we can see that the image is darker from when sigma is 1. When we look at the 7x7 size and 9x9 size, when the sigma value is 1 more effective in 7x7 and the sigma value is 2 more effective in 9x9. From these informations, we can say that when the size of the filter is big , increasing of the sigma value is better and the smoothing is better.

EXAMPLE 1 – KUWAHARA FILTER

The Kuwahara Filter is a non-linear smoothing filter for adaptive noise reduction. It is able to apply smoothing on the image while preserving the edges. The process of filtering Kuwahara is basically dividing a grid of pixels into four overlapping sub-grids and calculating a mean and variance for each. The output value is defined as the mean of the sub-grid that presents the least variation, and this value will be assigned to the central pixel of each region analyzed by the algorithm and can be used in a variety of ways with respect to this value.This filter is used for denoising images .

Original Image of Example 1

3x3 Kuwahara Filter of Example 1

5x5 Kuwahara Filter of Example 1

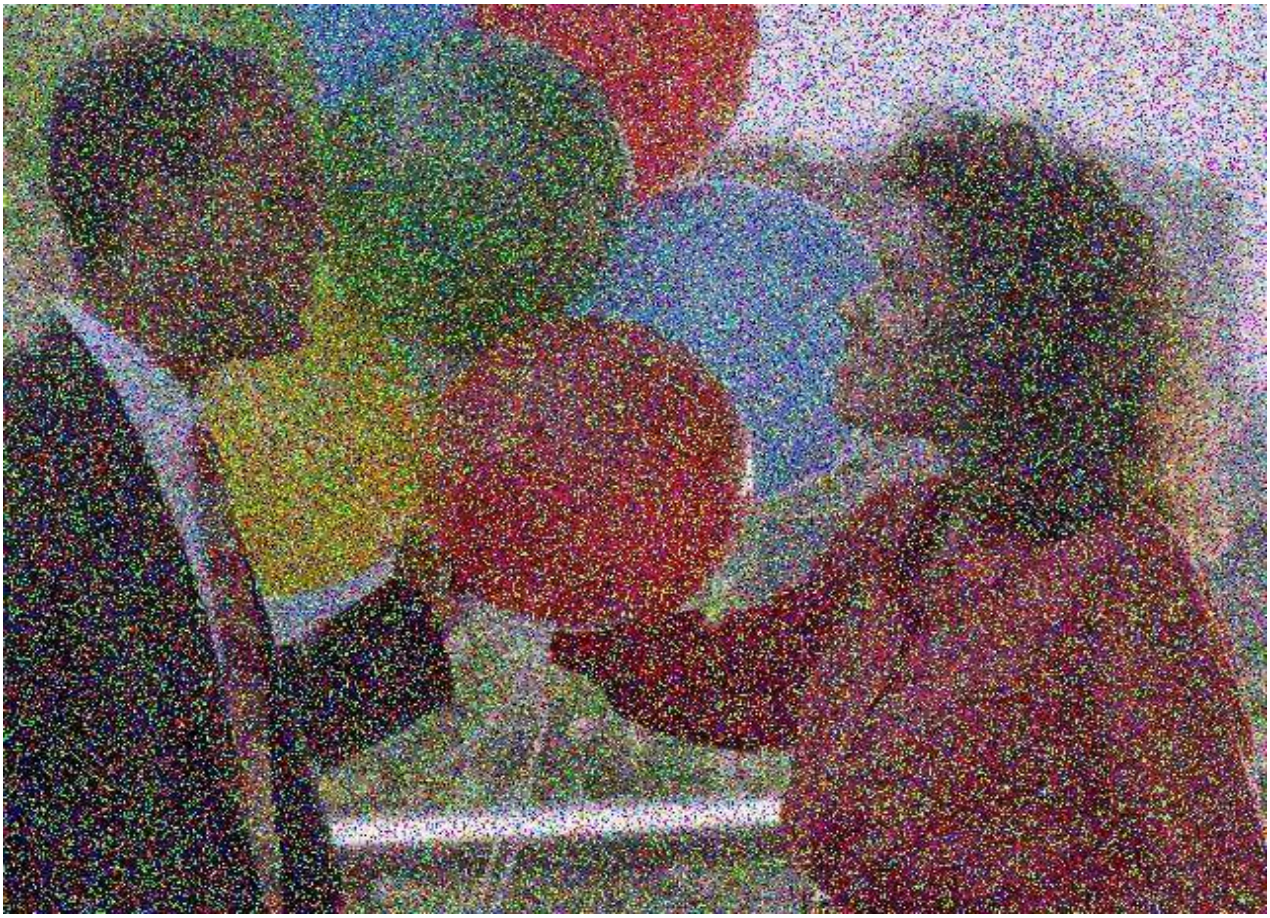
7x7 Kuwahara Filter of Example 1

9x9 Kuwahara Filter of Example 1

In the Kuwahara Filter, we can see that the noise reduction is little and the blur is little. After increasing the size 5x5, 7x7, and 9x9, the noise reduciton is better and also the blur is increasing compared to the smaller sizes. When we look at the all examples of Kuwahara filter , the smoothing is well but there are some blurs in details. Although there are blurs on the details, this filter is preserving the edges. We can say that the shapes in the image are not distorted.

There is an example of noisy image below. First, I will share the outputs of the filters according to the parameters, and finally I will share my comments for this example end of the images.

ORIGINAL IMAGE OF EXAMPLE 2(NOISY IMAGE)



3x3 MEAN FILTER

5x5 MEAN FILTER

7x7 MEAN FILTER

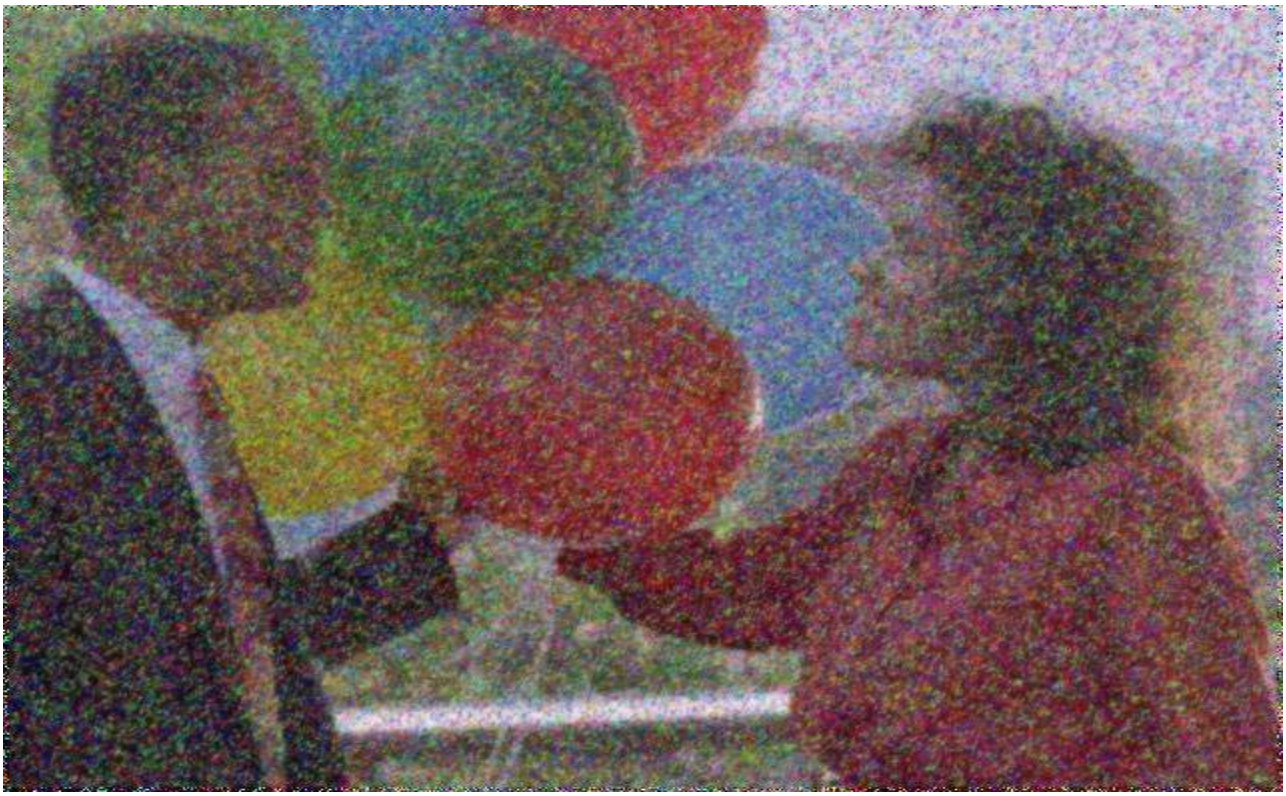
9x9 MEAN FILTER

Sigma:1

3x3 GAUSSIAN FILTER

5x5 GAUSSIAN FILTER

7x7 GAUSSIAN FILTER



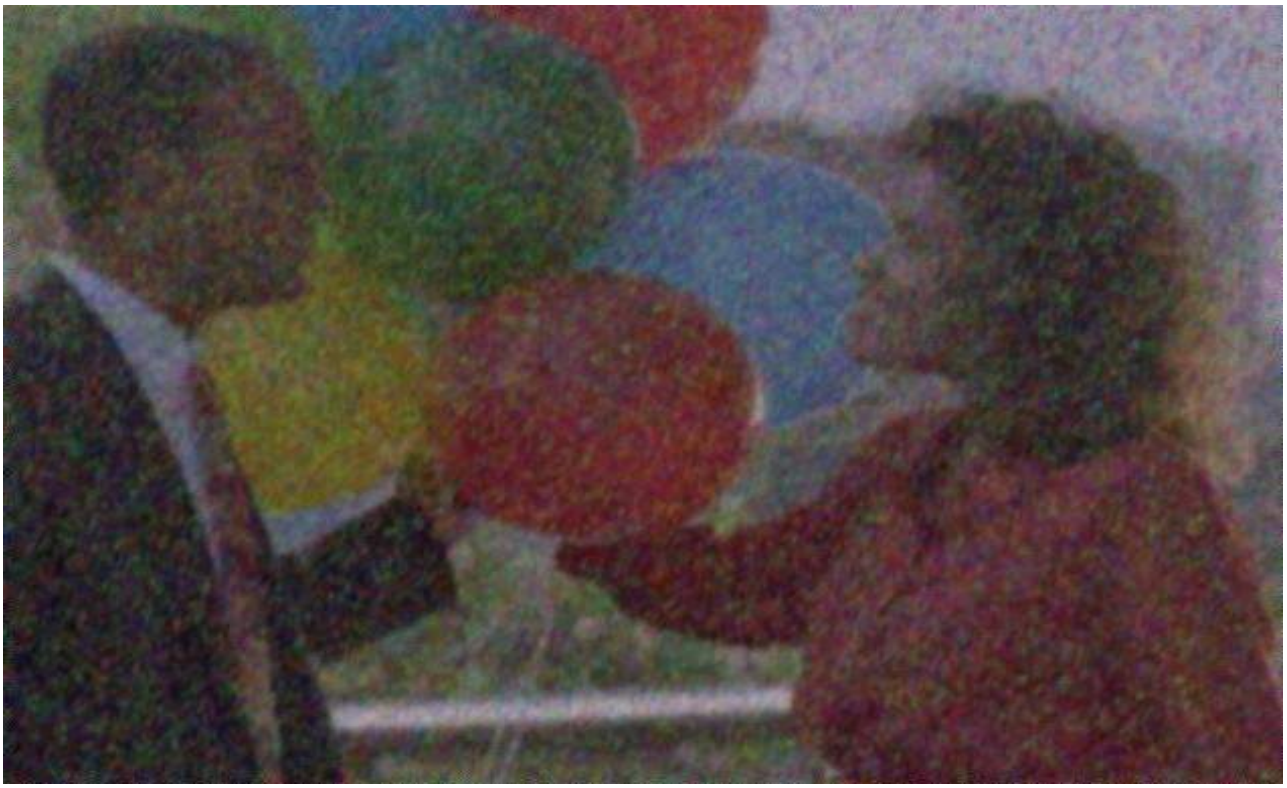
9x9 GAUSSIAN FILTER

Sigma:2

3x3 GAUSSIAN FILTER

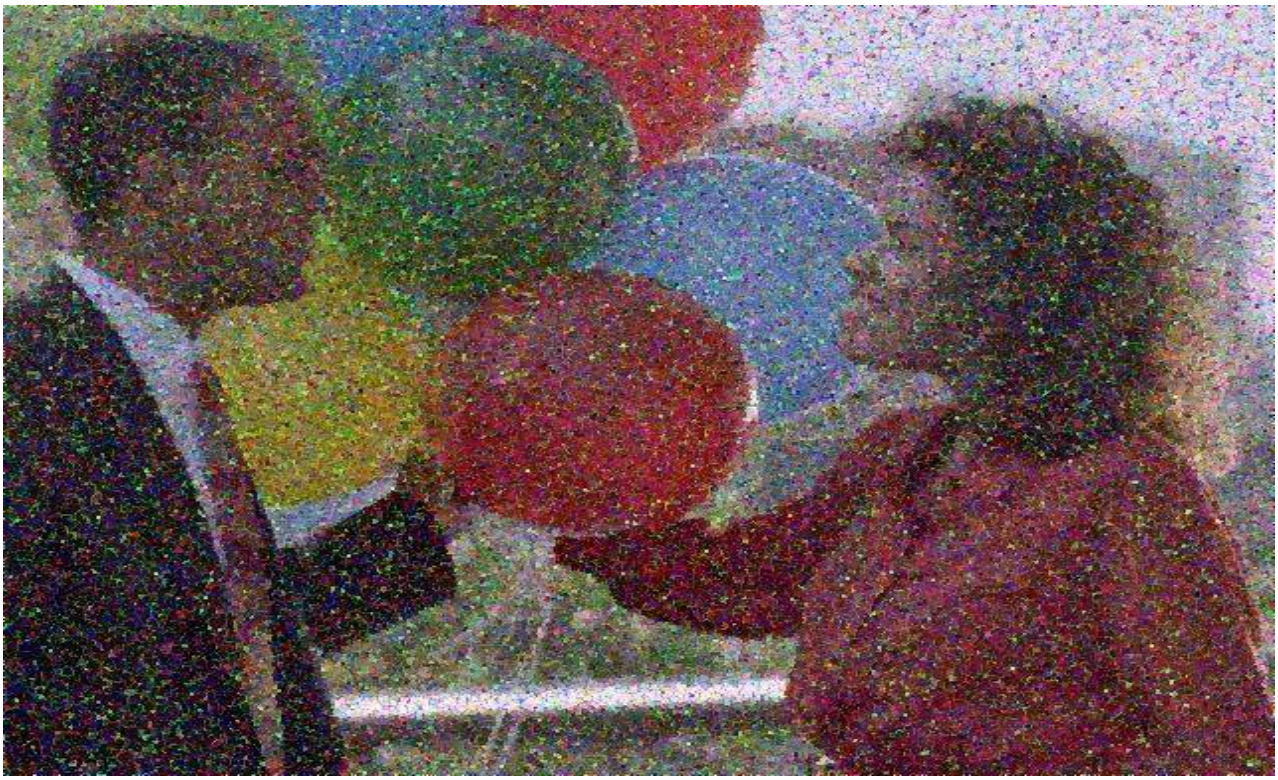
5x5 GAUSSIAN FILTER

7x7 GAUSSIAN FILTER



9x9 GAUSSIAN FILTER

3x3 KUWAHARA FILTER



5x5 KUWAHARA FILTER

7x7 KUWAHARA FILTER

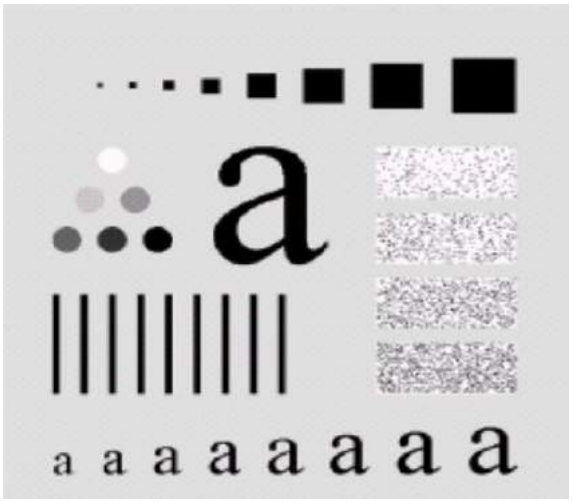
9x9 KUWAHARA FILTER

Mean filter in this example, reduces the noises in the image, and also blur the image. This filter is very simple,intuitive and easy to implement for smoothing images. When we don't need to protect details of image and we just want to smooth the image, we can use image filter.

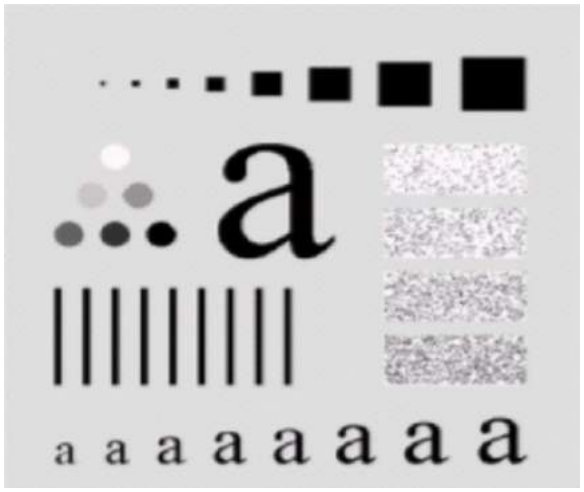
Gaussian filter in this example, we can see that the sigma value affects the image differently according to the size of the filter. When the size of the filter is small, we assign the sigma value small, or vice versa. This filter smoothes the image and reduces the noise in the image,too. But we can see that ,it blurs image less than Mean filter's blurring. The weightsgive higher significance to pixels near the edge (reduces edge blurring). But this filter takes long time to process.

Kuwahara filter is also reducing the noise of the image, but for the edges, it is very useful. Because of the implementation, the kuwahara filter reduces edge blurring too much compare to the other two filters. Also this filter takes too time to process.

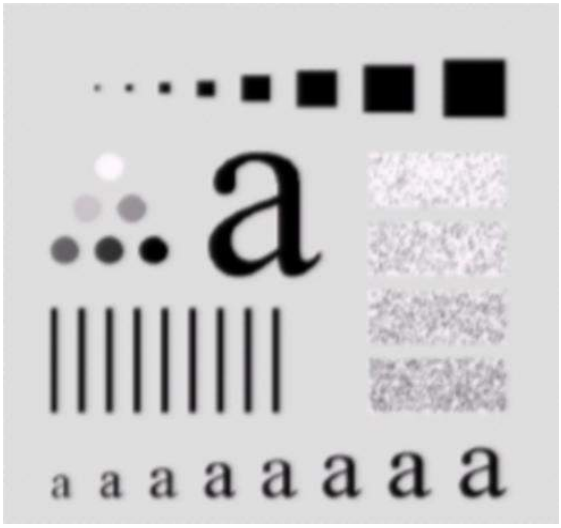
ORIGINAL IMAGE OF EXAMPLE 3



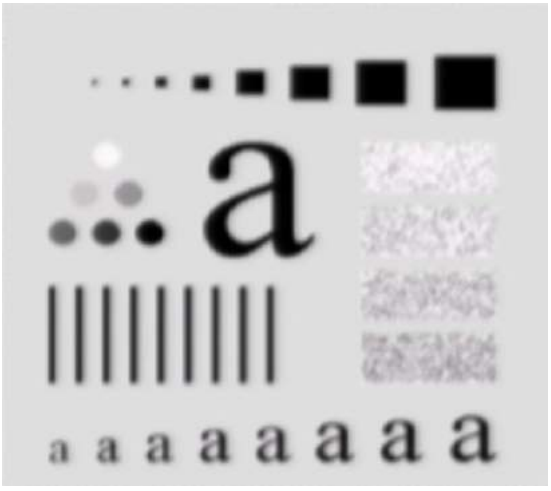
3x3 Mean Filter



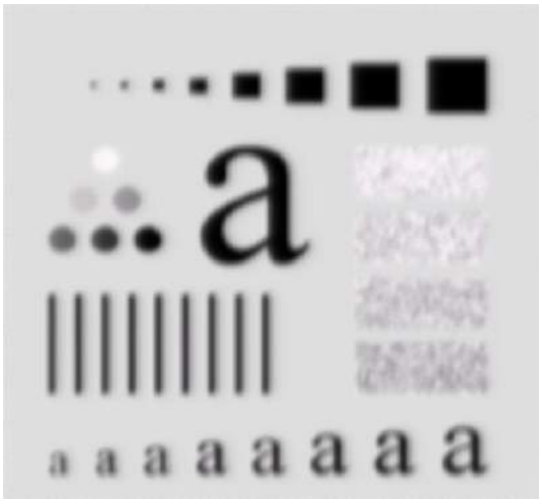
5x5 Mean Filter



7x7 Mean Filter

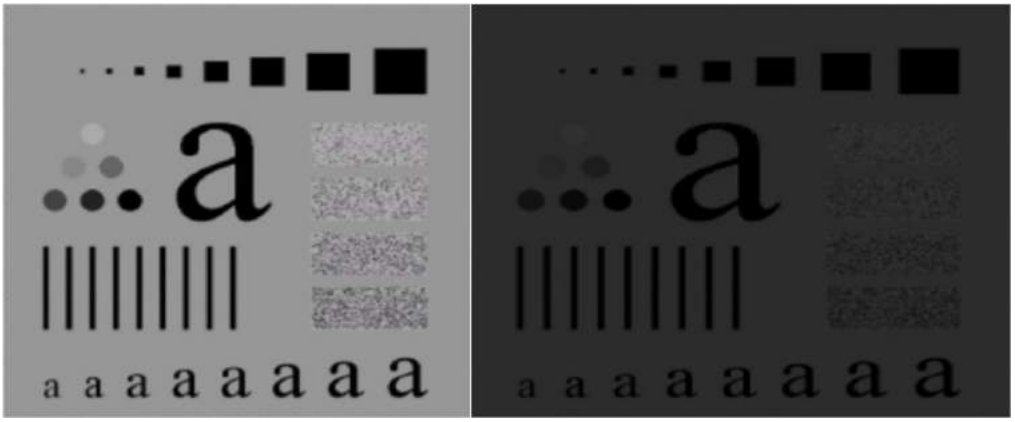


9x9 Mean Filter



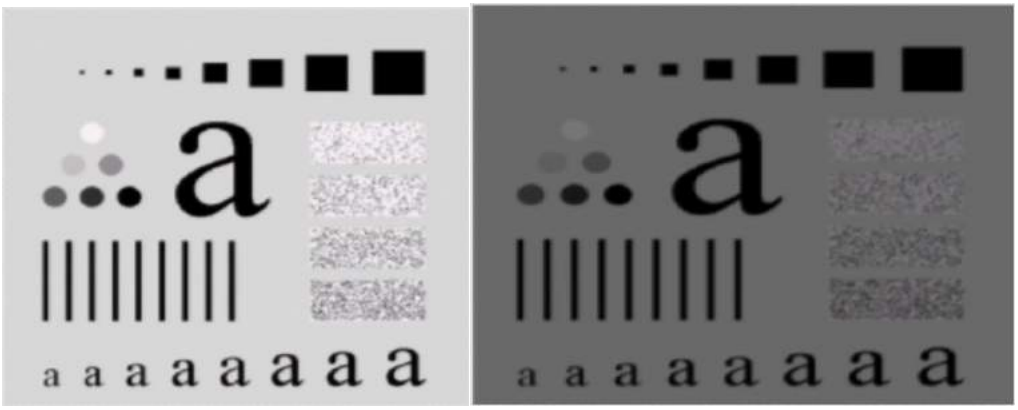
3x3 Gaussian Filter

Sigma:1 **Sigma: 2**



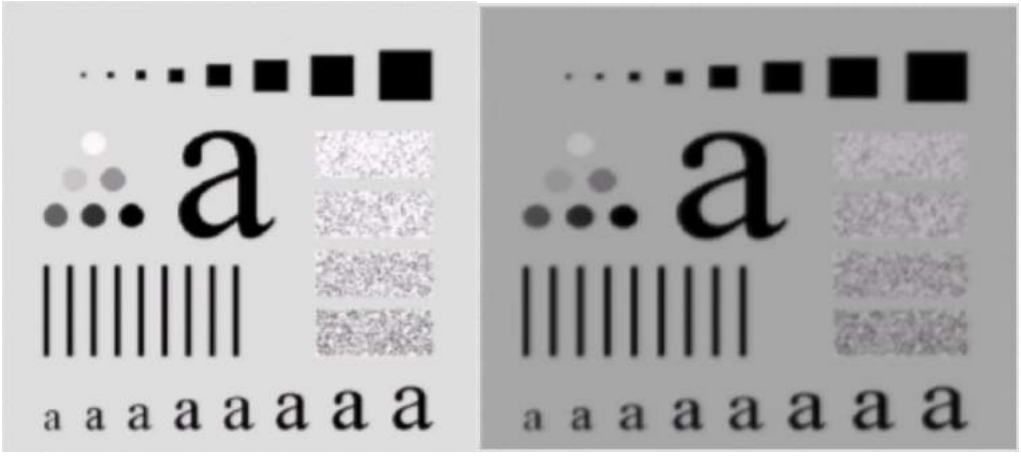
5x5 Gaussian Filter

Sigma:1 **Sigma:2**



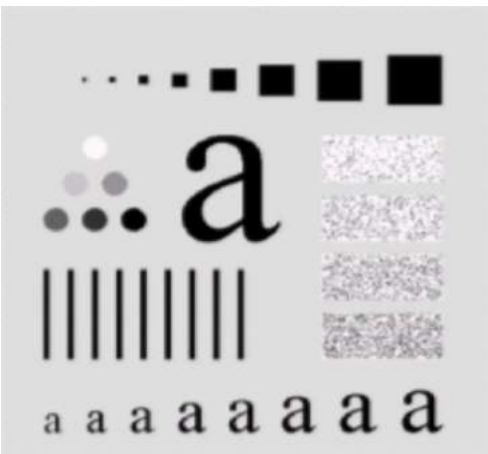
7x7 Gaussian Filter

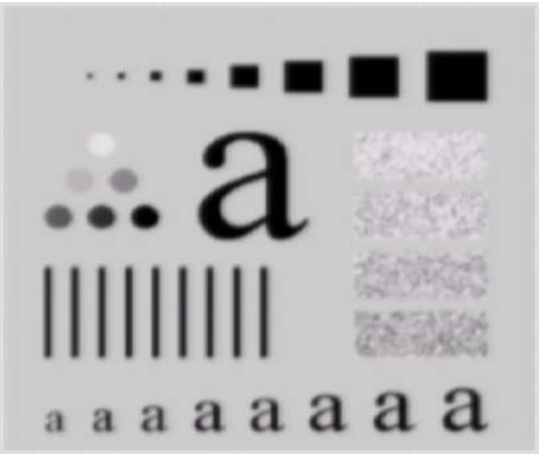
Sigma:1 **Sigma:2**



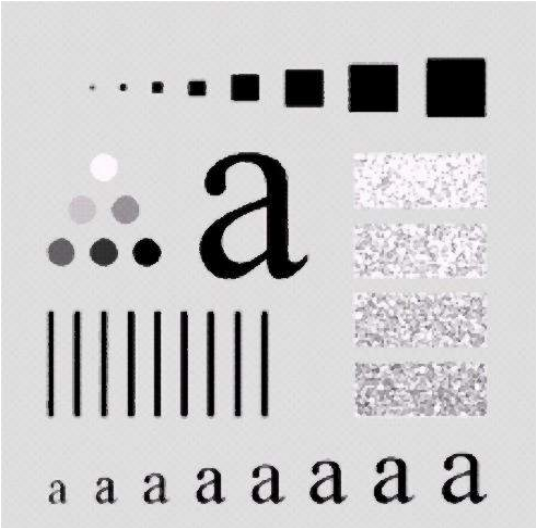
9x9 Gaussian Filter

Sigma:1 **Sigma:2**



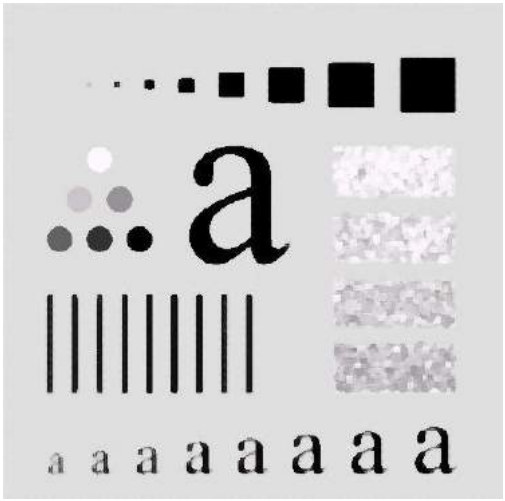


3x3 Kuwahara Filter

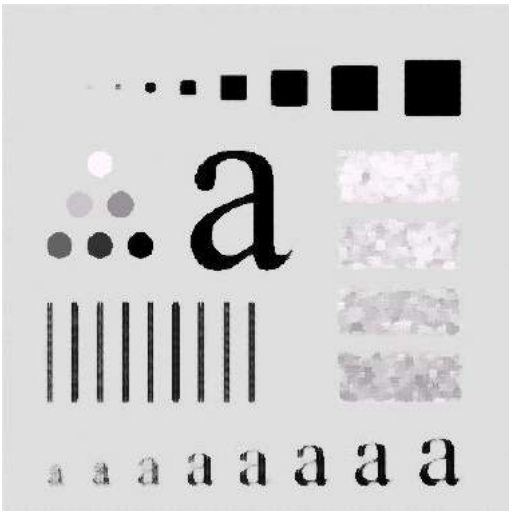


5x5 Kuwahara Filter

7x7 Kuwahara Filter



9x9 Kuwahara Filter



The Mean Filter in this example smoothes the image and also we can see that the image is too blurred.

The Gaussian Filter in this example smoothes the image and also we can see that the sigma value affects the filter differently according to the kernel size.

The Kuwahara Filter in this example smoothes the image and also reduce the noise very well and this filter blurred the image very few.

ORIGINAL IMAGE OF EXAMPLE 4

3x3 Mean Filter

5x5 Mean Filter

7x7 Mean Filter

9x9 Mean Filter

3x3 Gaussian Filter

Sigma : 1 **Sigma : 2**

5x5 Gaussian Filter

Sigma : 1 **Sigma : 2**

7x7 Gaussian Filter

Sigma : 1 **Sigma : 2**

9x9 Gaussian Filter

Sigma : 1

Sigma : 2

3x3 Kuwahara Filter

5x5 Kuwahara Filter

7x7 Kuwahara Filter

9x9 Kuwahara Filter

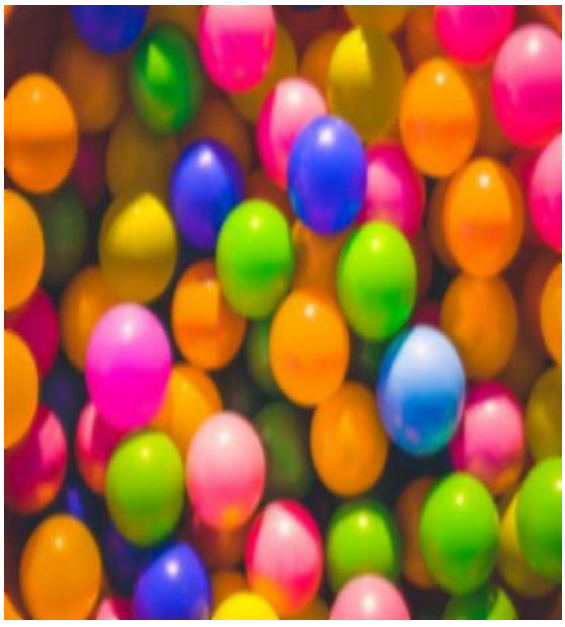
ORIGINAL IMAGE OF EXAMPLE 5

3x3 Mean Filter

5x5 Mean Filter

7x7 Mean Filter

9x9 Mean Filter



3x3 Gaussian Filter

Sigma : 1

Sigma : 2

5x5 Gaussian Filter

Sigma : 1

Sigma : 2

7x7 Gaussian Filter

Sigma : 1

Sigma : 2

9x9 Gaussian Filter

Sigma : 1

Sigma : 2

3x3 Kuwahara Filter

5x5 Kuwahara Filter

7x7 Kuwahara Filter

9x9 Kuwahara Filter

Conclusion

In this experiment, we are expected to implement Mean Filter, Gaussian Filter, and Kuwahara Filter with different sizes and parameters. I learned about these filters.Mean Filter is simple,and easy to implement. It is used for smoothing images and reducing noise in an image. Due to the calculation of this filter, the image is blurred when the filter applied to the image.Gaussian Filter is used for smoothing and reducing noise from an image. It is more complex and effective compare to the Mean Filter. Because of the weighted averaging in this filter, the blurring of the image is less than Mean Filter. Kuwahara filter is used for smoothing images and this filter is better the another two. It is reducing the noise and also the blurring is less than the others. Also, it is preserves the edges.