HACETTEPE UNIVERSITY
COMPUTER ENGINEERING DEPARTMENT

Image Processing

Assignment 2

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Mean Filter: The mean filter is widely using smoothing filter which can reduce on the image. It reduces the amount of intensity variation of neighbours pixels on the image. It perform as slicing window. It takes average of the pixels in the window and replaces with selected pixel.

Gaussian Filter: The Gaussian Filter mainly blurs images with Gaussian function. It reduces noise on the image, and also reduces details. It is very widely using application on the image processing.

Kuwahara Filter: The Kuwahara filter is a non-linear smoothing filter that has adaptive noise reduction. In that way, it reduces noise effectively, and also blur out the edges on the image. So, it applies smoothing image with preventing edges on the image.

Parameters and Their Effects

Mean filter: The mean filter has only one parameter that determines the kernel or window size of the filter. Mainly, the mean filter produces great results while blurring images or reducing noise.

As shown on the above example, mean filter has performs good image blurring. When we look at the wall of the buildings, there are lots of many small dots due to the structure of the wall. But on the filtered image, it is hardly see these details. So we can say that, mean filter reduces details, and also noises. Maybe in this image it was not a noise but it has the same logic so that it can reduce noises just like the image in below.

Original

Mean with 9x9

When we change the parameter of mean filter (the kernel size) image become more smoother, and of course less details. It can be seen below images.

Gaussian filter: The Gaussian filter has two different parameters for working. One of them is kernel size like a mean filter, the other one is sigma value. Changing kernel size when sigma = 1, the picture becomes more smooth and less noisy. But it is a very small effect unlike in the mean. When we look at the 9x9 and 15x15 pictures especially, there is almost no change at all. But we can see the differences from the original one even it is slightly.

Original

Gaussian 3x3

Gaussian 5x5

Gaussian 9x9

Gaussian 15x15

Also I checked the sigma parameter changes and it is changed the smoothing effect, but not too much just like the kernel size. (Picture order: original, sigma 0.5, sigma 1, sigma 4)

Kuwahara filter: The Kuwahara filter is a non-linear filter and it does adaptive noise reduction. It has a different effect from the other algorithms we have seen especially on the edges of the image. It splits the kernel into four different areas and calculates standard deviations for each of them. Then it chooses the lowest std area and calculates its mean. In the end, it replaces the pixel with this mean value. I did it in my code with an HSV format image. The difference is I calculate STDs with brightness values in the HSV values. When applying this filter it has very different and good effects on the images. It has one parameter and it is the kernel size. While kernel size increases, the smoothing effect also increases as shown below. When we look at the texts on the signs, it is disappearing while the kernel size increase due to the effect of the Kuwahara on the edges. Also, when we checked the flowers on the image, we can see the differences from other filters. (Order: original, 3, 5, 9, 15)

Explanation of Behaviour of The Filtering Methods

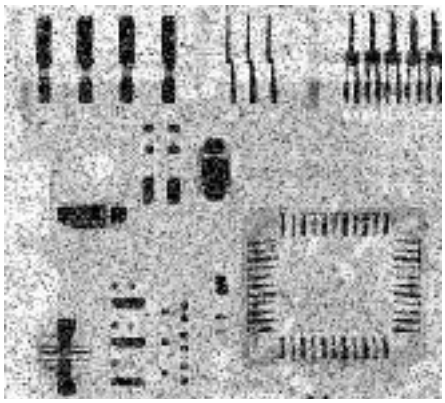
Mean filter

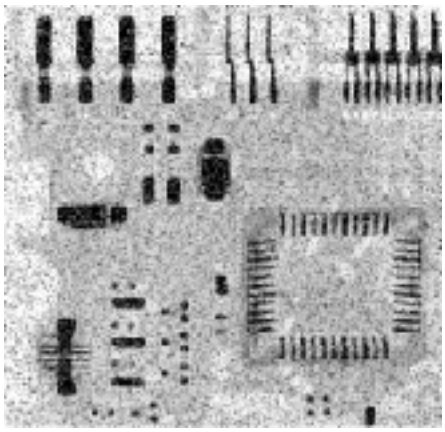
Mean filter is good for smoothing images. It has good results for general smoothing but it doesn't care for the edges. So, if it is important to prevent edges while smoothing it is not the best I think. The example is shown below. In this example we can see that the details and the edges become less visible.

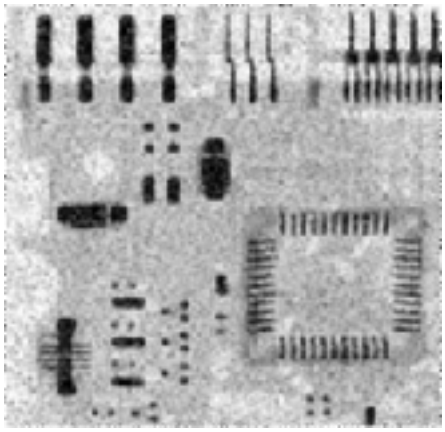
Original

Mean with 9x9

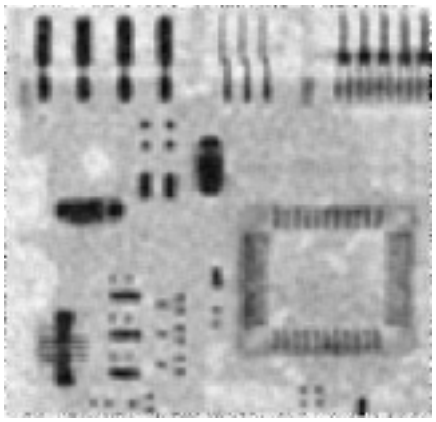
In the salt and pepper noise images, it has good results especially the simplicity of the algorithm. The example below with order of original, 3x3, 5x5, 9x9, 15x15.



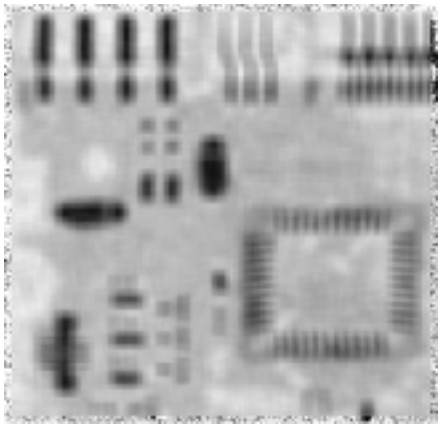




I



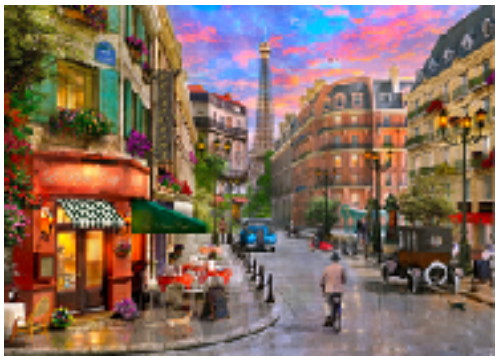
think

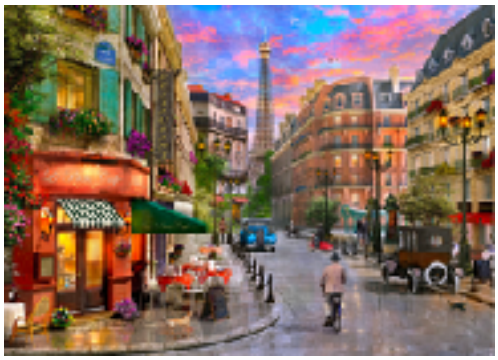


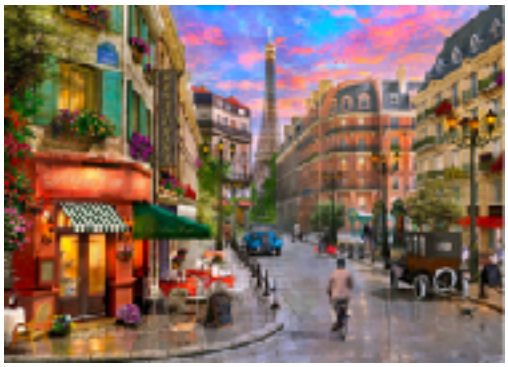
we got good results with kernel sizes 5 and 9. As we said before, there is a loss of edge details but generally, it has a good effect on the pepper salt noise.

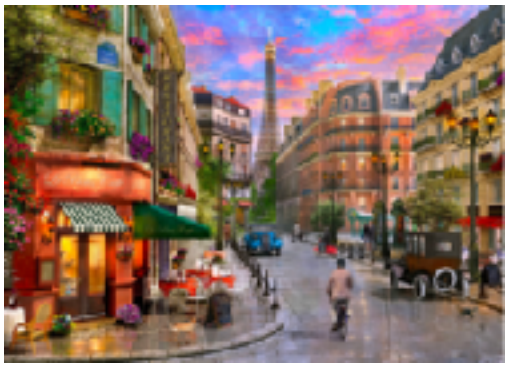
Gaussian filter

The Gaussian filter has good results but it doesn't affect the images as we see in the mean filter. But on the other side, gaussian blurring prevents edges very well. We can see the smoothing effects on the texts and the details on the images. The result getting with sigma = 2. (order: original, 3x3, 5x5, 9x9, 15x15)

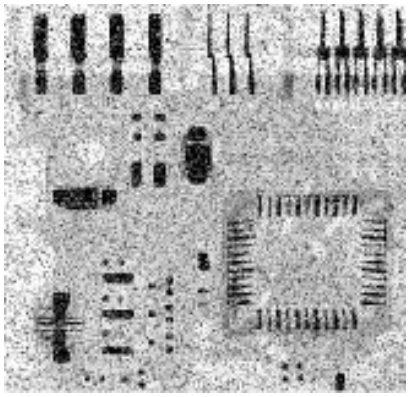
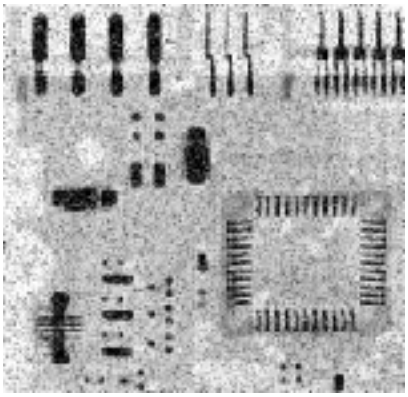
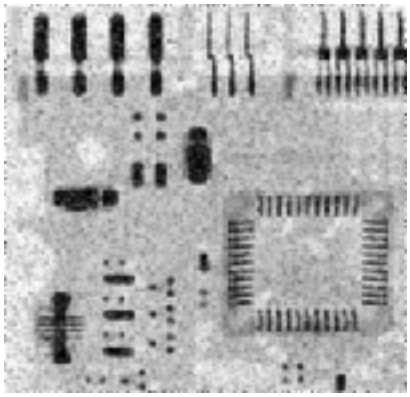
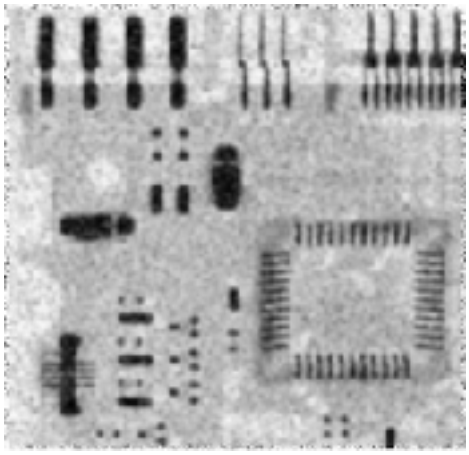
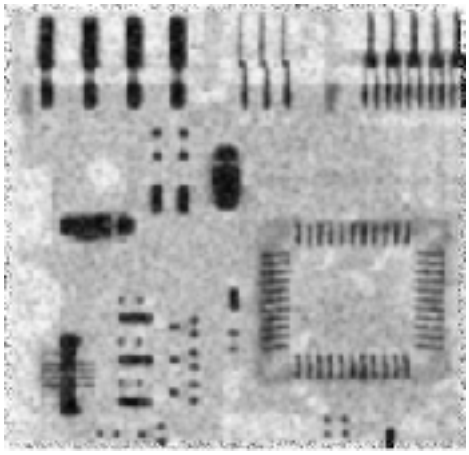






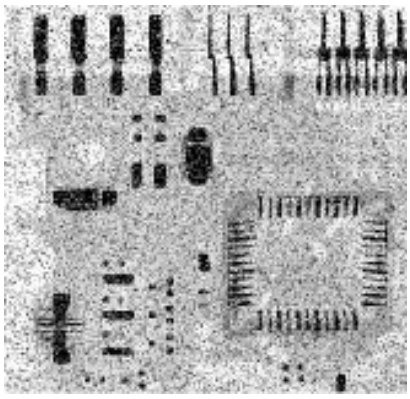


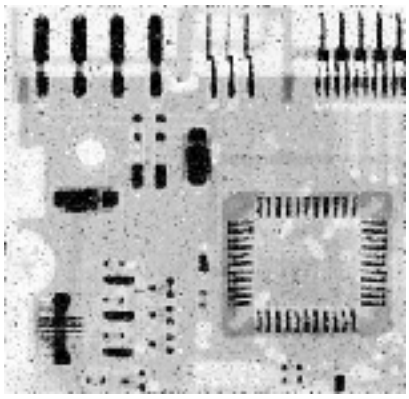
Also, I check the effect of the gaussian blur on the pepper salt noise image. It has very good results I think. It reduces lots of pepper and salt noises, and while doing this, it prevents the edges well. The 5x5 and 9x9 have a very good result. If you want a more detailed image, you can use it. But if you want more smooth, you can use 15x15 or 9x9. (Order: original, 3x3, 5x5, 9x9, 15x15)

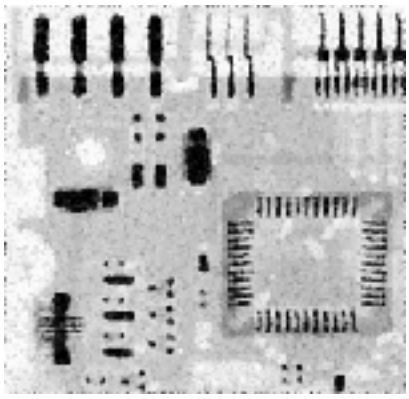






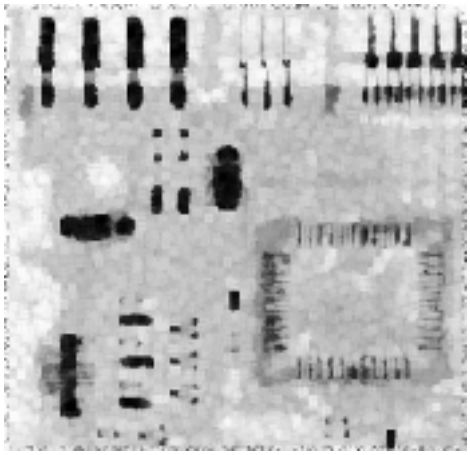
Kuwahara filter: The Kuwahara filter using for adaptive noise reduction. It tries to apply smoothing to the image while preserving the edges. In my experience, it is doing a very good job for that purpose especially when we compare our other filters. The Kuwahara has a very different output and it prevents the edges from blurring. Of course not the perfect way but it is doing it well. But in some cases, it is looking at the image, not a real one. It looks like a painting made with crayons. This case happens while the kernel size increases. You can check the good results with a 3x3 filter and bad results in the 15x15 images. (Order: original, 3x3, 5x5, 9x9, 15x15)

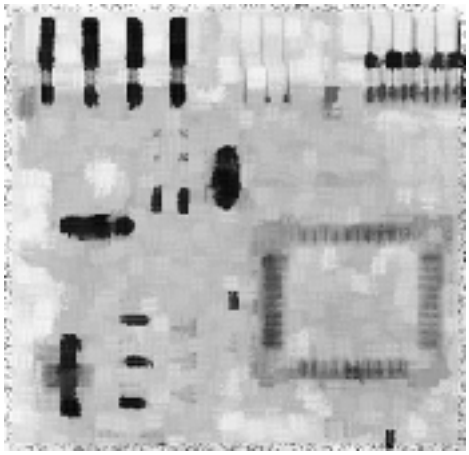
When we check Kuwahara with pepper salt noise image, it has a great job in well-chosen kernel size. The below images show the Kawahara filter's performance in this situation. When checking the results, we can see the Kuwahara filter is a very impressive result on the image created with a 5x5 kernel size. (Order: original, 3x3, 5x5, 9x9, 15x15)











Comment About Difference Between Filters

When we look at the mean, gaussian, and Kuwahara filters, there are lots of differences between Kuwahara and the others. I think mean and gaussian have not too many differences. The mean filter has good results in general smoothing operations. Also, it has a very simple algorithm, so everybody can easily apply it. On the other side, gaussian can be very useful in the image that effected by noise. The Kuwahara is also very good in that job. It prevents the edges from smoothing. (Order: original, mean, gaussian, kuwahara)

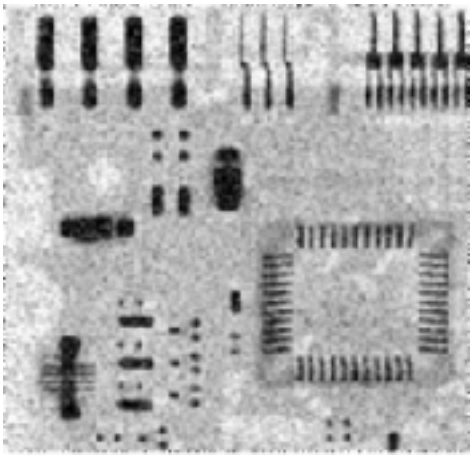


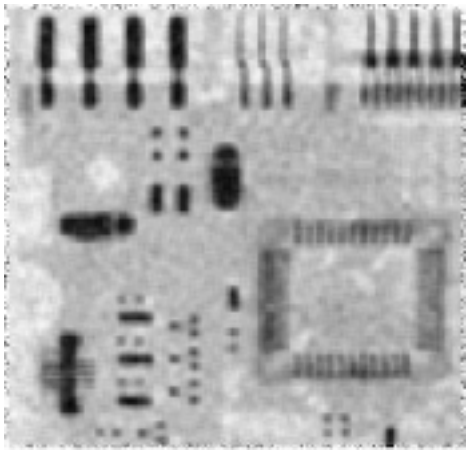

When we look at the images mean and gaussian very good results for blurring images if details or edges are not important too much. I think these filters can be used in the bokeh effect on the images. Also, gaussian can be used with good parameters in machine learning for setting the images. The Kuwahara is very

different from these. It is blurring but different kinds of. These differences can be affected by the inequality of the parameters but it is very hard to find equal parameters for different filters. I tried to closest ones for comparison. In this situation, the texts on the sign are less readable on the Kuwahara. But it tried the out more clear edges. We can see the edges on the walls. Kuwahara has more clear edge lines.

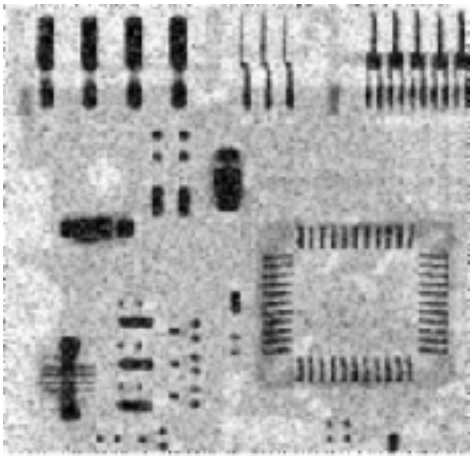
Also, noise reduction is also important when it comes to image processing. It is used in many different areas. In this situation, each of them can extract good results. The mean and gaussian has very similar effects on the images in most situations. In the below examples, we can see that. But there are some minor changes that become gaussian better. For example, mean prevent on the first image but it has too much noise still. In the other image, there is good noise reduction but the important details are missed, I think. On the other hand, the second gaussian image has a very good result for this situation. It has good noise reduction, and also good edges and details. The Kuwahara is very different in this situation too. I produce very clear images in both. The First can be not good for the good noise reduction, but the second one has the best result I think. It is very clear, has very small noise, and has impressive edge and details.

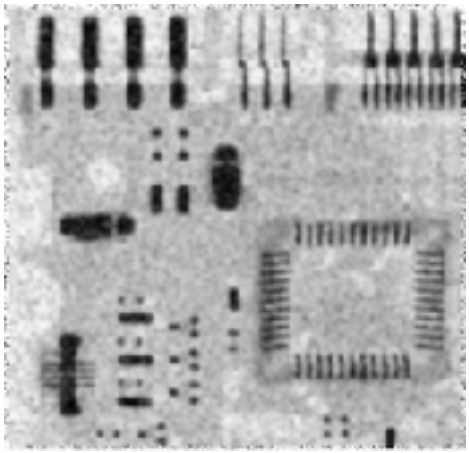
Mean :



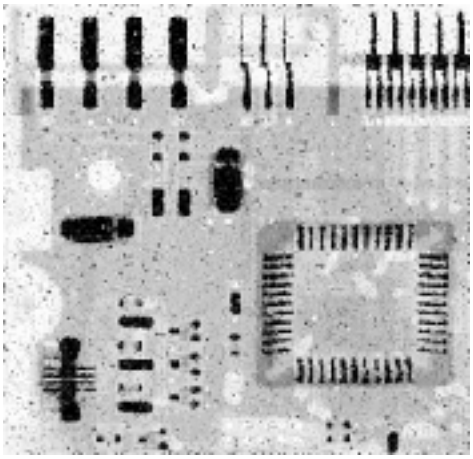


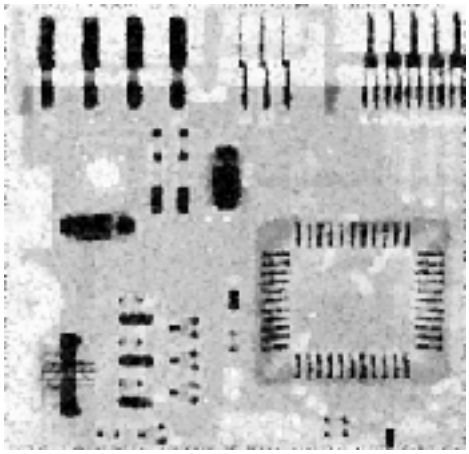
Gaussian :





Kuwahara:





Notes: I did my implementations with changing the beginning index for filters. Because of that, the outputs images have original pixels on the edge of the image as you can see in the outputs. I create my functions depending on the research I did, and there were very different kinds of implementations for the same algorithm. I tried to create the best implementation for our assignment. In the comment I did, I tried the find good images to extract the prominent features of the algorithms. To do that, I tried the filters in 10-15 different images and put the seven different images in my report.