INFOIVB A1: Filters and Edges Report

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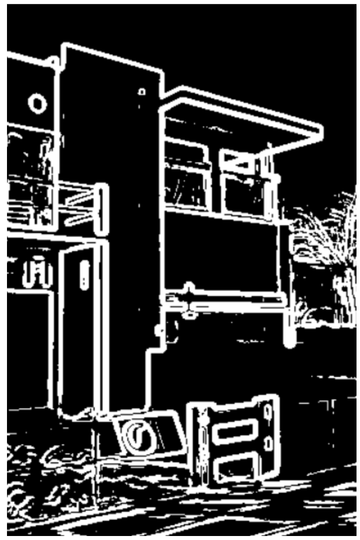
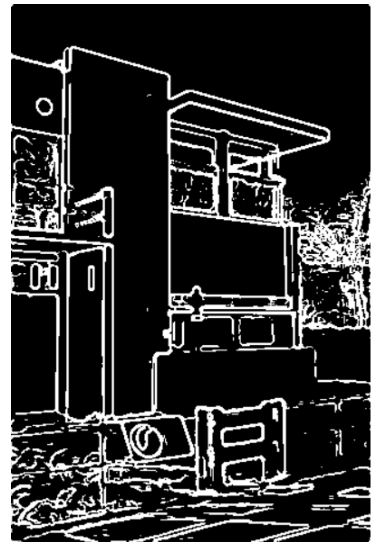
1. Comparison of images A, B and C:


(image A: grayscale)


(image B: Gaussian filter)


(image C: median filter)

The only difference in generating images B and C is the filter. Image B applied a Gaussian filter, while image C used the median filter. As shown in the pictures above, the major difference between the output of the two filters is the edge's thickness and the ability to capture detail.

In image B, with a Gaussian filter, the edges appear thicker and the noise is also less than in image C. The image becomes smoother because the Gaussian filter applies a weight across the pixels, where the neighboring pixels influence each other based on the normal distribution. The benefit of it is the noise reduction, yet, it also blurs fine detail at the same time.

In the image C, with a median filter, the edge appears thinner and maintains more detail. This is because the median filler works by replacing each pixel value with the median value of the surrounding pixels; such a method helps to prevent the edge while excluding the noise and removing outlier from it.

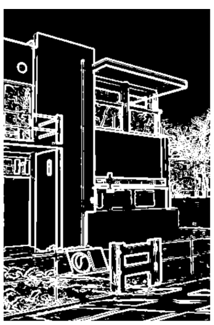
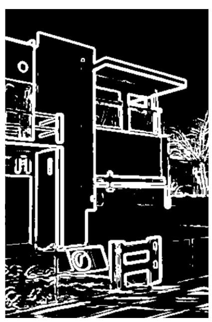
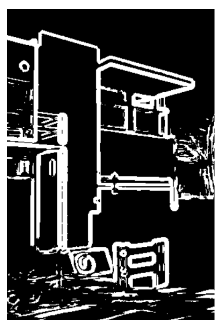
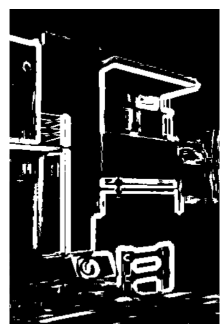
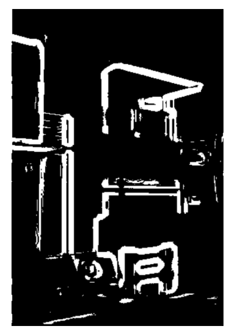
2. Motivation behind choice of kernel and parameters (e.g. threshold) in obtaining images B and C.

The Sobel kernels were used for both gx and gy because it is able to emphasize the edges in the horizontal and vertical directions. The Sobel operator gives a smoother gradient compared to simpler operators, which reduces sensitivity to noise and can also preserve the edge strengths, which in turn helps detect stronger, well-defined edges in both pipelines one and two.

In Pipeline one, firstly the data was converted into grayscale to simplify the color data. Then contrast adjustment was applied in order to help enhance the edges by increasing the difference between the darker and the lighter regions, which is beneficial for edge detection later on in the pipeline. A Gaussian filter was then applied with size 5x5 and a standard deviation (sigma) of 3. A Gaussian filter usually blurs the image and reduces noise before applying edge detection upon the image. The choice of a larger kernel size (5x5) with a higher standard deviation value (3) ensures that smaller, less relevant edges caused by noise are smoothed out, allowing only the most important edges to be detected. After the edge detection, a threshold of 30 is applied on the image. This threshold value is low enough such that it is able to retain the weaker edges but high enough to eliminate insignificant details. Another reason is that the Gaussian filter has already smoothed out most of the noise.

In Pipeline two, similarly to Pipeline one we convert the image to grayscale and apply contrast adjustment on it. However, instead of a Guassian filter, we use a median filter instead, of size 5x5. The median filter is effective at preserving edges while removing noise, like salt-and-pepper. Then, edge detection is applied with the same Sobel kernels. Compared to Pipeline one, a higher threshold value of 40 is used because the median filter preserves sharp edges, making weaker edges less significant, so a higher threshold value is able to effectively remove the less important edges.

3. The trend of increasing Gaussian kernel size and corresponding increasing sigma.

				
D1:3x3, sigma=2	D2: 5x5, sigma=3	D3: 7x7, sigma=4	D4: 9x9, sigma=5	D5: 11x11, sigma=6

The above binary images (D1, D2, …, D5) represent the increasing Gaussian kernel size and the corresponding sigma. We observe that as the Gaussian kernel size and sigma increase, the image becomes more simplified, more detail is missing and the edge becomes thicker. The main reason for the trend is due to the role of the Gaussian kernel and sigma.

The Gaussian kernel determines the extent of the neighborhood around the pixel, which is going to compute the new value to smooth the image. The larger the kernel size, the more neighborhoods are going to contribute and influence the blur. In other words, as the kernel size increases, more detail and noise will be smoothed out, leading to a loss of sharpness. On the other hand, the sigma controls the amount of blurring. It defines the standard deviation of the function in Gaussian, the higher value causes the more significant feature to remain while the detail vanishes. Therefore, with the larger kernel size and sigma, more blurring occurs, only the most significant edges will be left while the other will be ignored.