Image Filtering Report

1. Introduction

This report discusses the application of spatial domain filters on a grayscale version of a facial image (`modi.jpg`). The filters applied include:

- Average Filter
- Gaussian Filter
- Laplacian Filter
- Sobel Filter (for edge detection)
- Median Filter

These filters are commonly used in image processing to enhance features, reduce noise, and detect edges in an image. Each filter has its own characteristics and use cases.

2. Image Preprocessing

Before applying the filters, the input image is first converted into grayscale. Grayscale images are easier to process for filtering tasks, as they contain intensity information without color channels.

Grayscale Conversion

A manual conversion was performed using the formula:

Where:

- R,G,BR, G, B are the red, green, and blue components of the image.

If the image was already in grayscale (single channel), it was directly processed without any conversion.

3. Spatial Filters

3.1 Average Filter

The average filter is a simple linear filter that works by averaging the pixels in a neighborhood. For this implementation, a 3×33 \times 3 kernel is used with all values equal to 19\frac{1}{9}. This helps to blur the image and reduce noise.

Kernel:

The average filter works by computing the mean of pixel values in a 3×33 \times 3 region around each pixel, effectively smoothing the image.

3.2 Gaussian Filter

The Gaussian filter is a low-pass filter used to blur the image and reduce noise. It uses a Gaussian function to calculate the weights. For this task, a 3×33 \times 3 kernel with σ=1\sigma = 1 is used.

Kernel:

The kernel is normalized so that the sum of all its elements is 1. The filter smooths the image while retaining important features like edges.

3.3 Laplacian Filter

The Laplacian filter is a second-order derivative filter used for edge detection. It highlights areas of rapid intensity change and is often used for edge detection or sharpening.

Kernel:

It detects areas where there is a significant change in pixel intensity, providing sharp edges and transitions in the image.

3.4 Sobel Filter

The Sobel filter is used for edge detection. It computes the gradient of the image intensity in both the horizontal and vertical directions using two kernels: one for detecting horizontal edges and another for vertical edges.

Kernel:

By calculating the gradient magnitude using both xx- and yy-direction gradients, we can highlight edges in the image.

3.5 Median Filter

The median filter is a non-linear filter used to remove noise, especially "salt and pepper" noise. It works by replacing each pixel value with the median value of the pixels in its neighborhood.

For this task, a 3×33 \times 3 window is used, and for each pixel, the values in the window are sorted, and the median is selected as the new pixel value.

4. Results

4.1 Output Images

The results of applying the above filters are shown below:

1. **Original Grayscale Image:** This is the converted grayscale version of the original image.

2. **Average Filter:** The image appears smoother and blurred, with less detail.

3. **Gaussian Filter:** Similar to the average filter, but with smoother transitions, reducing noise more effectively.

4. **Laplacian Filter:** Highlights edges and sharp transitions in the image.

5. **Sobel Filter:** Detects edges in the image, both horizontally and vertically.

6. **Median Filter:** Effectively reduces salt-and-pepper noise while preserving edges.

4.2 Display of Filtered Images

The filtered images are displayed side by side for comparison, showing the effect of each filter on the grayscale image.

5. Conclusion

In this exercise, we successfully applied several spatial filters to an image. Each filter has its own purpose:

- The **average** and **Gaussian** filters are used for smoothing and noise reduction.

- The **Laplacian** and **Sobel** filters are used for edge detection, highlighting transitions in pixel intensities.

- The **median filter** effectively removes noise, especially salt-and-pepper noise, without blurring the image too much.

This demonstrates the importance of spatial domain filters in image processing for various tasks such as noise reduction and edge detection.
