Faculty of Engineering & Technology

Electrical & Computer Engineering Department

Computer Vision

ENCS5343

Assignment 1

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Section: 2

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Contents

Table of Figures

1 Q1

1.1 Image used for Q1

The image below used for the first question, with the following properties: 8-bit gray-level,

256x256 pixels in size.

Figure 1. Q1 Figure

Then several filters and noises were applied to it.

1.2 Power Law Transformation with Gamma=0.4

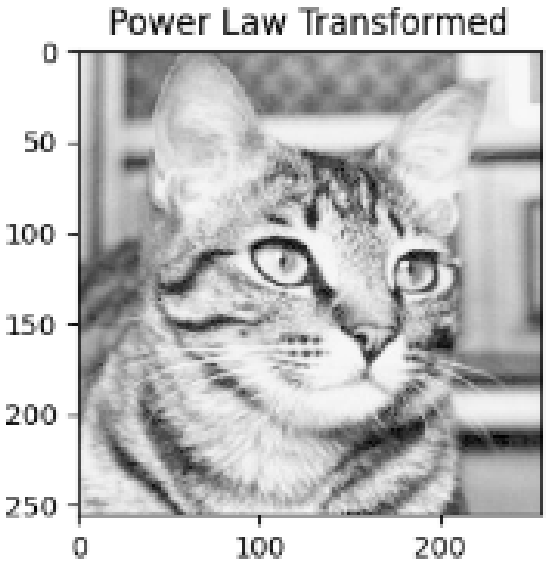

Figure 2. Power Law Transformed image

The transformation alters the pixel values of the original image using a power law function. This function boosts the gamma value of each pixel value to a particular power. The gamma value in this situation is 0.4.

A gamma value of 0.4 compresses the original image's middle range of pixel values. This means that the grayscale tones between dark and light become more similar. The following was noted:

- Increased contrast in dark and bright areas
- Mid-tone detail is reduced

1.3 Zero-mean Gaussian Noise

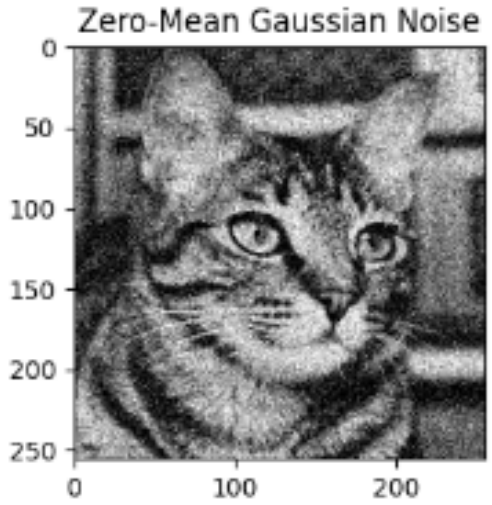

Figure 3. Zero-mean Gaussian noise image with 40 Gray-levels

The grainy texture that covers the image clearly shows the effects of Gaussian noise.

Since this noise is "zero-mean," or has an average value of zero, it has little effect on the image's overall brightness. It creates a soft, grainy texture without totally hiding the cat's face's underlying characteristics.

1.4 Mean Filter on Zero-mean Gaussian Noise

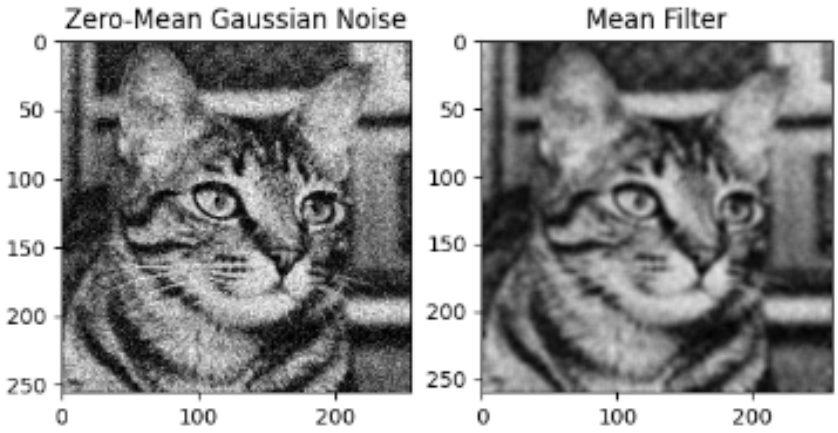

Figure 4. Zero-mean Gaussian Noise with Mean Filter (5x5)

The following were noticed:

- **Decreased noise:** results in a smoother, less grainy image.
- **Diminished sharpness:** causes the image's edges and tiny features to become blurry when information from nearby pixels combines. A minor reduction of clarity and sharpness may result from this.

1.5 Median Filter on Salt and Pepper Noise

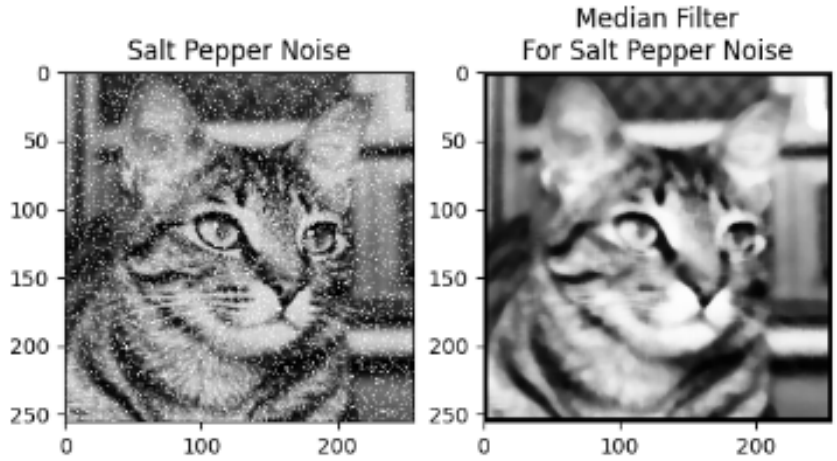

Figure 5. Salt and Pepper (0.1 noise-density) with Median filter (7x7)

The following were noticed:

- **Reduced noise:** The noise artifacts that resemble pepper and salt are much diminished by the median filter, which efficiently replaces the isolated black and white noise pixels with values closer to their surrounding neighbors.
- **Edges are preserved:** The median filter preserves the image's edges and small features, in contrast to averaging filters. By choosing the medium value, you may maintain the edges of objects and characteristics, such as the cat's eyes, nose, and fur markings, while still respecting the current intensity fluctuations.
- **Smoothing effect:** The median filter can slightly smooth the noise while also reducing it, particularly in areas with uniform intensity. This may result in a look that is marginally less textured than the source picture.

1.6 Mean filter on Salt and Pepper Noisy-image

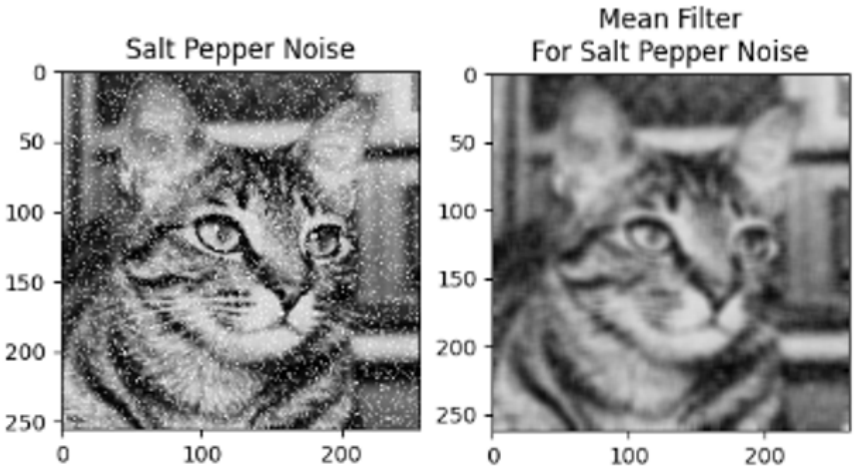

Figure 6. Salt and Pepper (0.1 noise-density) with Mean filter (7x7)

Mean filters work well at mitigating Gaussian noise, but they're not the best option for eliminating pepper and salt noise for a number of reasons:

- **Noise amplification:** In some circumstances, the salt and pepper noise may actually be amplified due to the mean filter's averaging feature. The average value may still be inside the noise range if the kernel size includes both a noisy pixel and its nearby clean neighbors, creating a "pepper" or "salt" spreading effect.

- **Blurring of edges and small features in an image:** Mean filters have the same effect as Gaussian noise reduction. We want to maintain the distinct transitions between clean and noisy pixels; therefore, this is undesirable when dealing with salt and pepper noise.

1.7 Sobel Filter

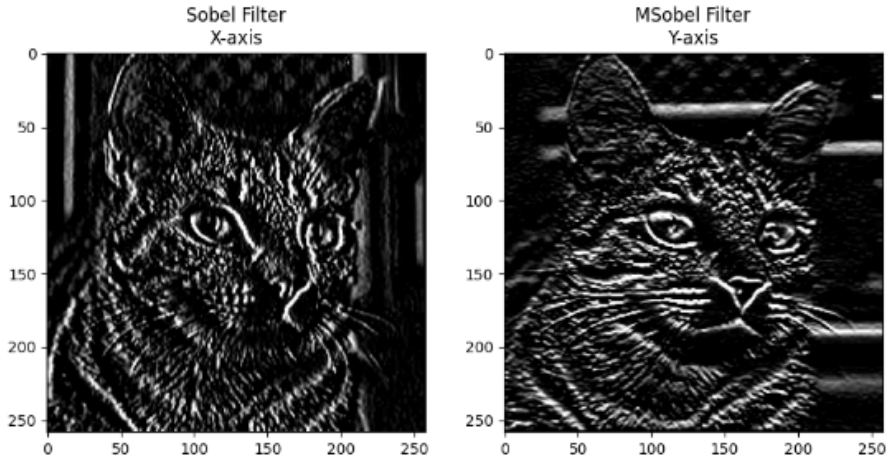

Figure 7. Sobel filter in X and Y direction

- **Enhanced edges:** The edges of the cat's characteristics, such its eyes, nose, whiskers, and fur markings, are highlighted by the filter. The features on the cat's face are emphasized by these edges, which seem sharper and more defined.
- **Less detail in smooth areas:** Because the filter only picks up high-frequency variations in intensity, parts of the picture with smooth intensity transitions seem less detailed or even featureless.

Two distinct pictures are produced by the Sobel filter; one represents the gradient in a horizontal direction and the other in a vertical one. You may obtain a more comprehensive view of the edge directions in the original image by merging these photos. For example, the nose may have a larger vertical gradient than the eyes, which may have a stronger horizontal gradient.

2 Q2

2.1 Averaging Kernel

2.1.1 House1 image

Figure 8. House1 with Averaging Filter (3x3)

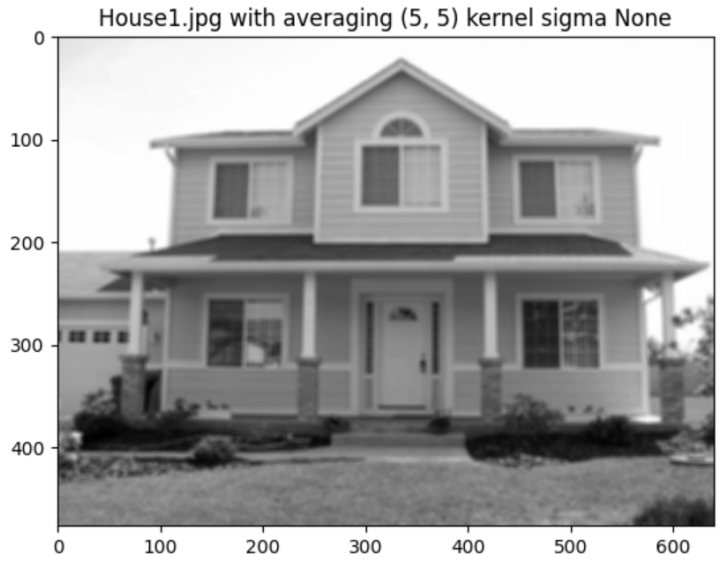

Figure 9. House1 with Averaging Filter (5x5)

2.1.2 House2 image

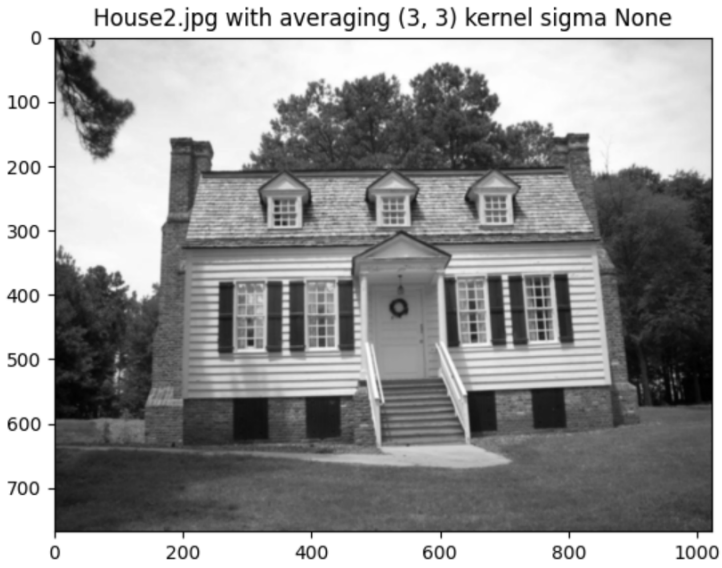

Figure 10. House2 with Averaging Filter (3x3)

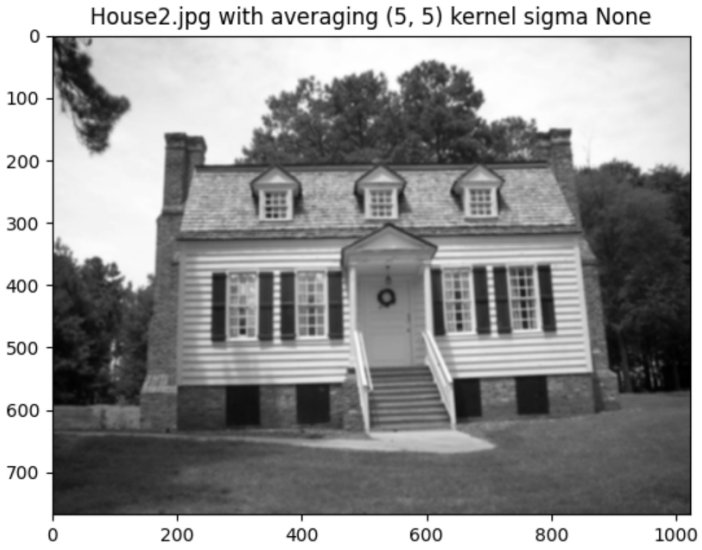

Figure 11. House2 with Averaging Filter (5x5)

Every grayscale pixel in the photos has a filter applied to it, which replaces its intensity value with the average of the intensity values of the pixels in the selected kernel that surround it. With the averaging filter applied, the windows, roof, and door edges become softer.

A greater area surrounds each pixel as the filter size increases. The image may lose subtle features and textures as a result of this. For instance, a bigger filter size may mask minute differences in the house's brickwork or shading.

2.2 Gaussian Kernel

2.2.1 House1 image

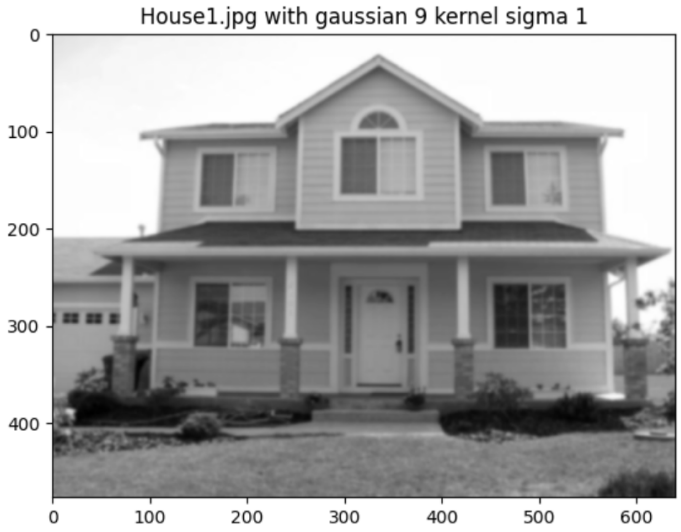

Figure 12. House1 with Gaussian Noise (sigma = 1)

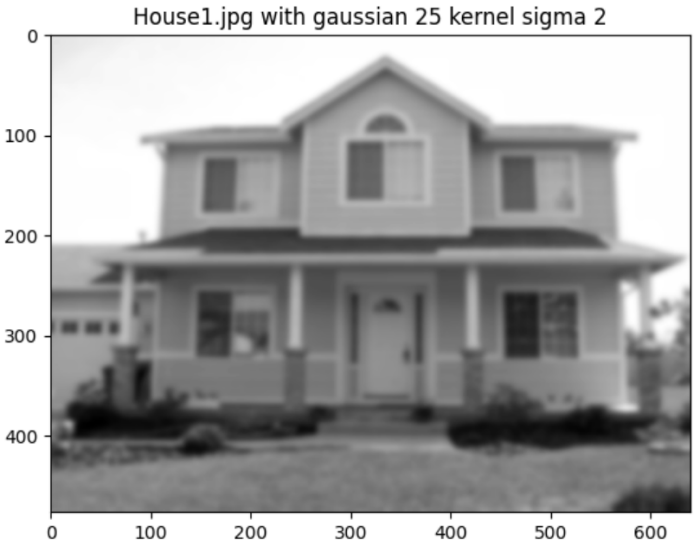

Figure 13. House1 with Gaussian Noise (sigma = 2)

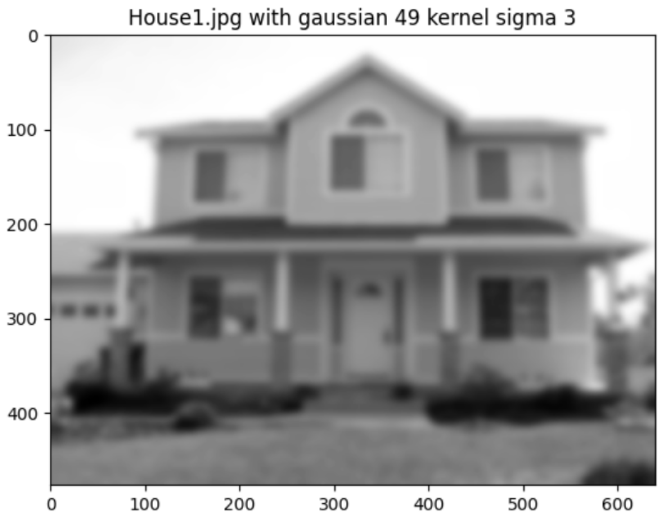

Figure 14. House1 with Gaussian Noise (sigma = 3)

2.2.2 House2 image

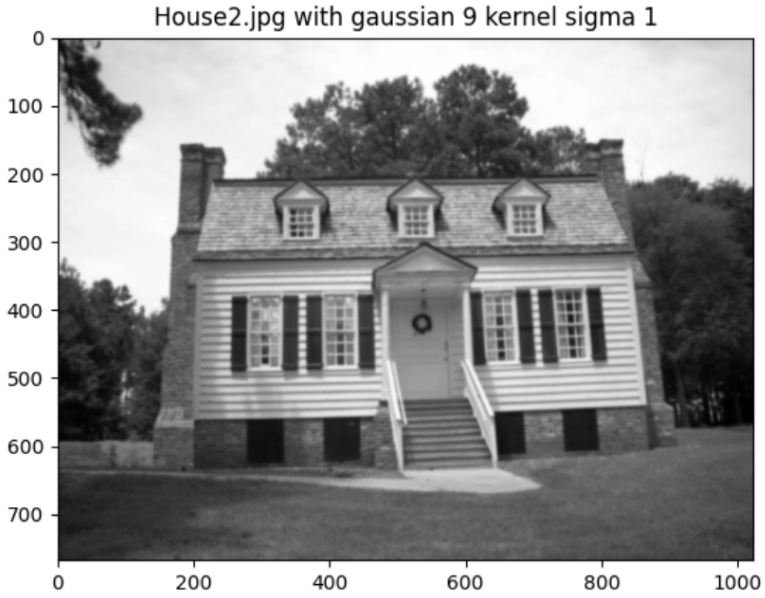

Figure 15. House2 with Gaussian Noise (sigma = 1)

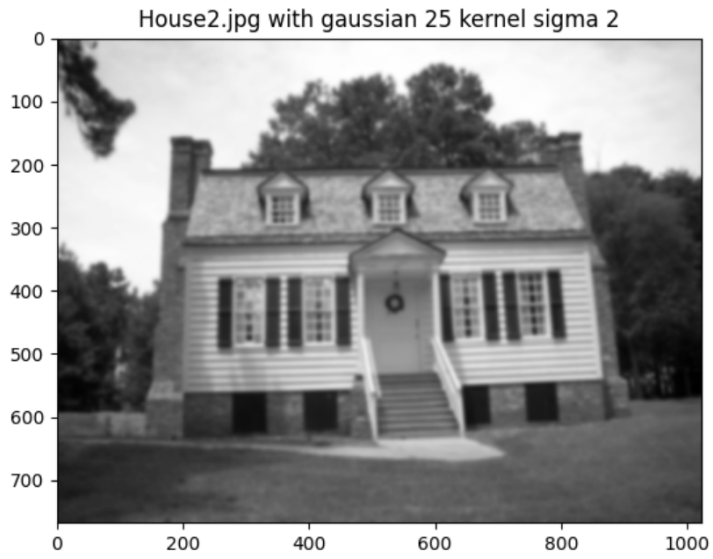

Figure 16. House2 with Gaussian Noise (sigma = 2)

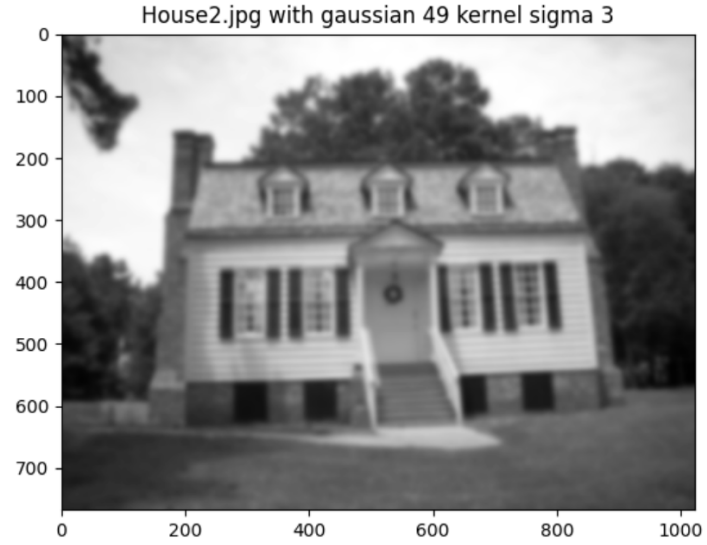

Figure 17. House2 with Gaussian Noise (sigma = 3)

The Gaussian function's "spread" is regulated by sigma. Observing the two images, we noted the following:

- **Increased smoothing:** As the filter's effect becomes more noticeable, edge blurring and detail loss intensifies.
- **A greater range of nearby pixels is captured:** which may allow it to remove a wider variety of noise.
- **Smoother transitions:** produce a blur that is more gradual and realistic-looking.

2.3 Sobel Edge Operators

2.3.1 House1 image

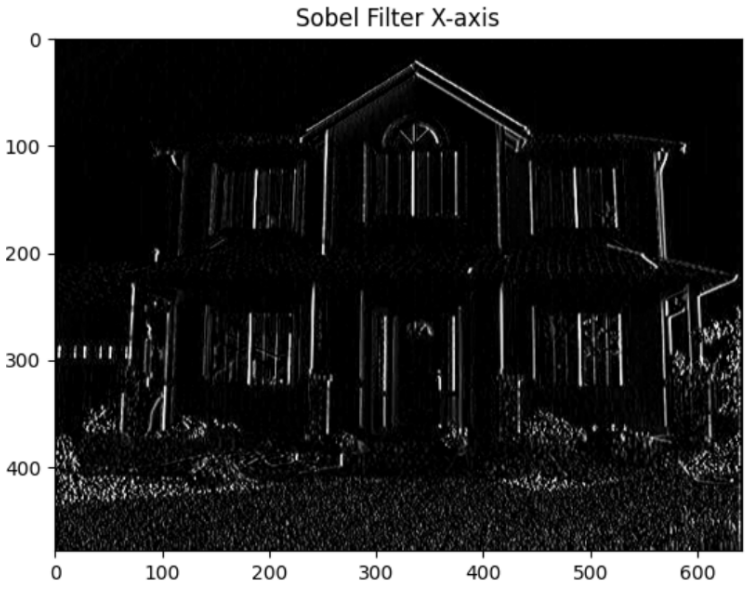

Figure 18. House1 with Sobel Filter (X direction)

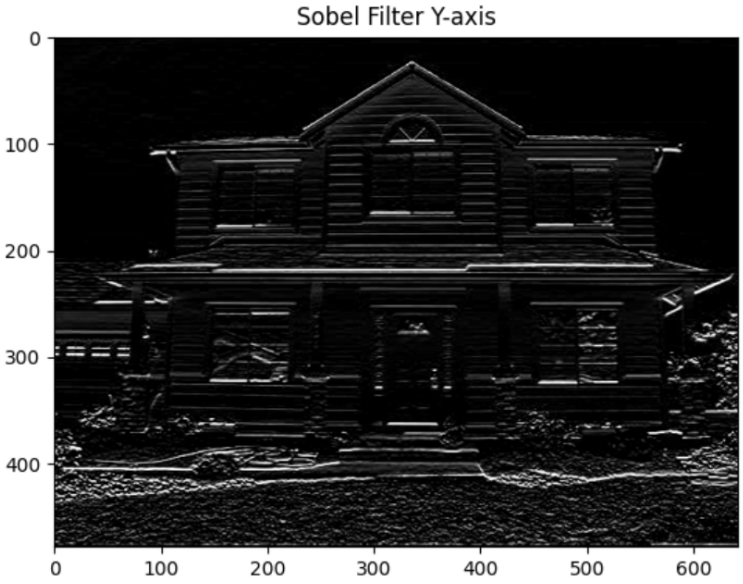

Figure 19. House1 with Sobel Filter (Y direction)

2.3.2 House2 image

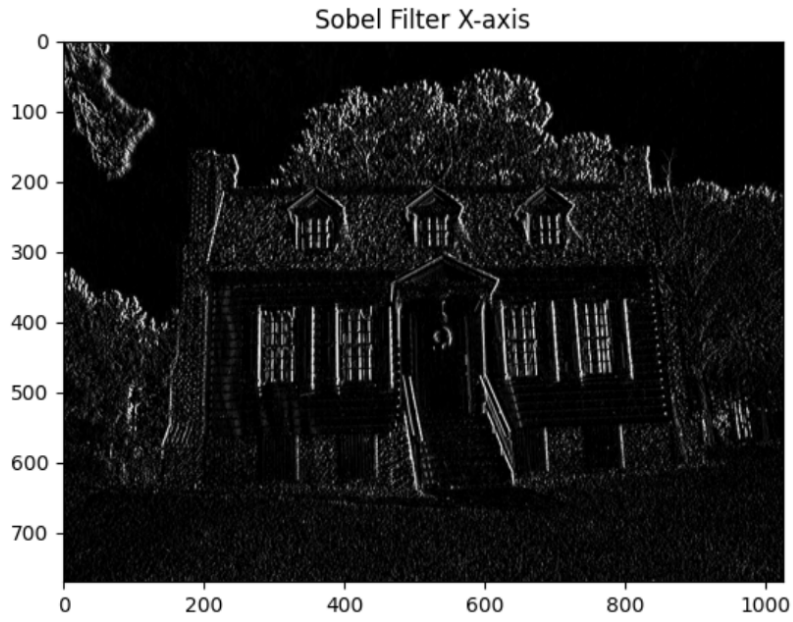

Figure 20. House2 with Sobel Filter (X direction)

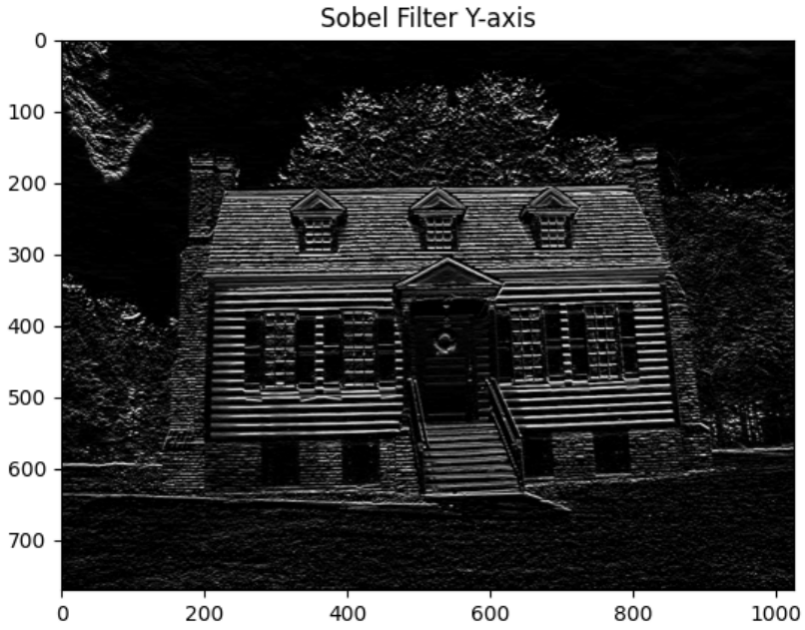

Figure 21. House2 with Sobel Filter (Y direction)

2.4 Prewitt Edge Operators

2.4.1 House1 image

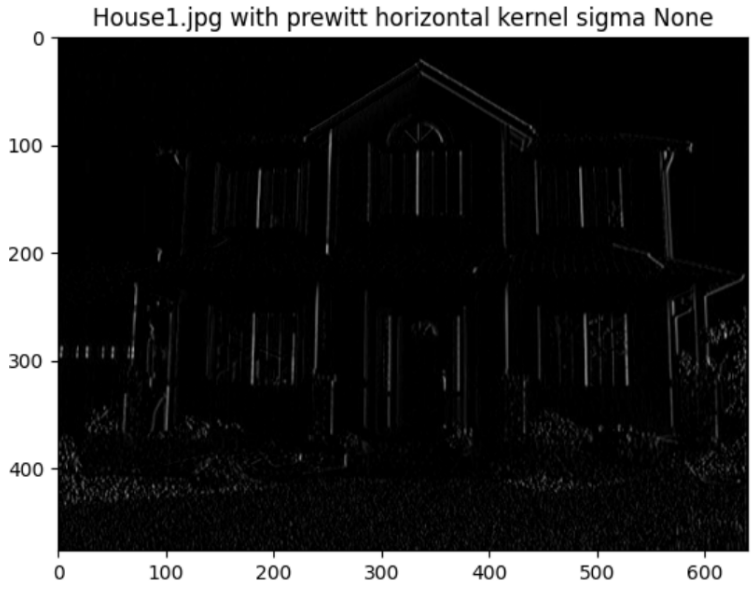

Figure 22. House1 with Prewitt Filter (Horizontal)

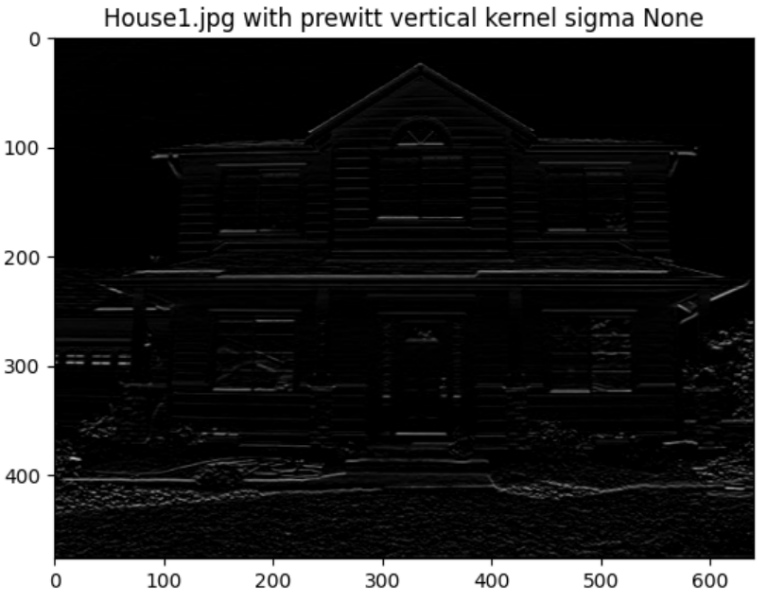

Figure 23. House1 with Prewitt Filter (Vertical)

2.4.2 House2 image

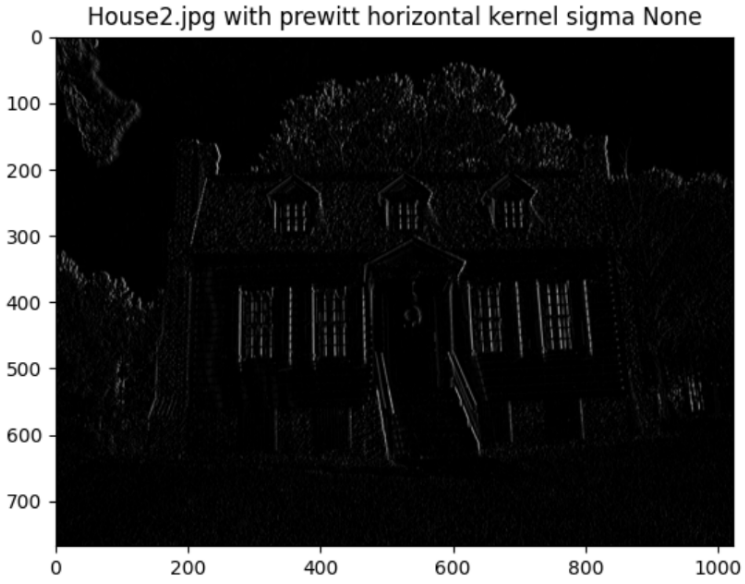

Figure 24. House2 with Prewitt Filter (Horizontal)

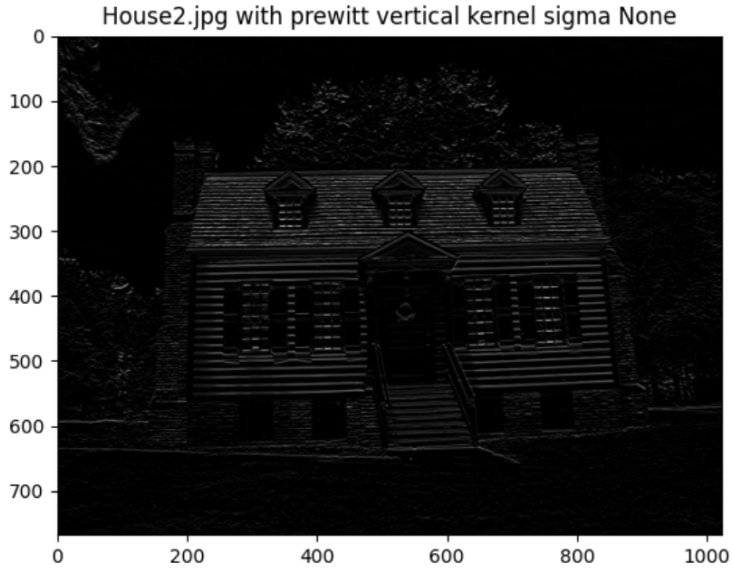

Figure 25. House2 with Prewitt Filter (Vertical)

Comparing Sobel and Prewitt:

- **Edge detection:** The Sobel filter often yields significantly sharper and more noticeable edges, but both filters are successful at identifying edges.
- **Directional sensitivity:** The Sobel filter is primarily focused on horizontal and vertical edges, whereas the Prewitt filter is more sensitive to diagonal edges.

3 Q3

3.1 Averaging Filter

3.1.1 Noisy Image 1

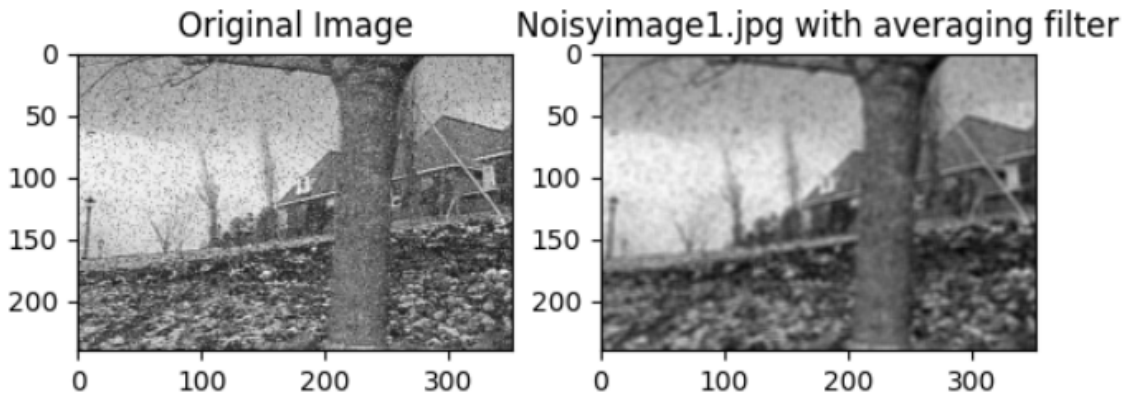

Figure 26. Noisy Image1 with Averaging Filter (5x5)

3.1.2 Noisy Image 2

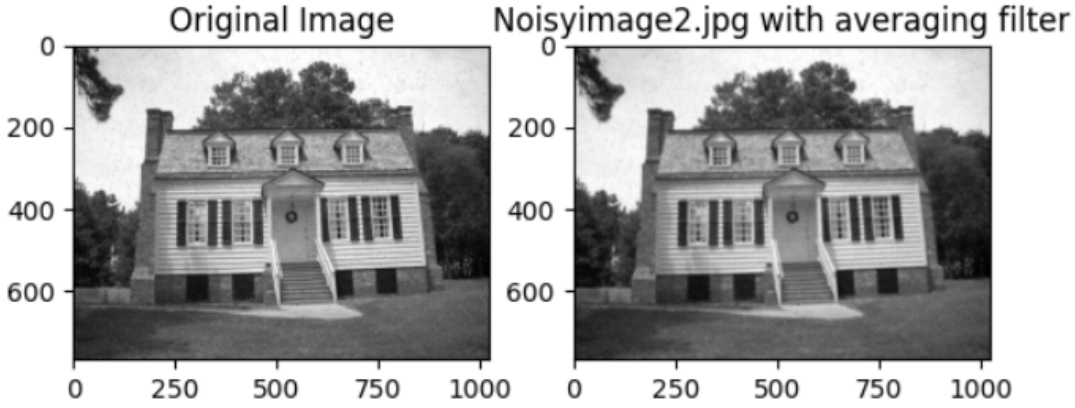

Figure 27. Noisy Image2 with Averaging Filter (5x5)

3.2 Median Filter

3.2.1 Noisy Image 1

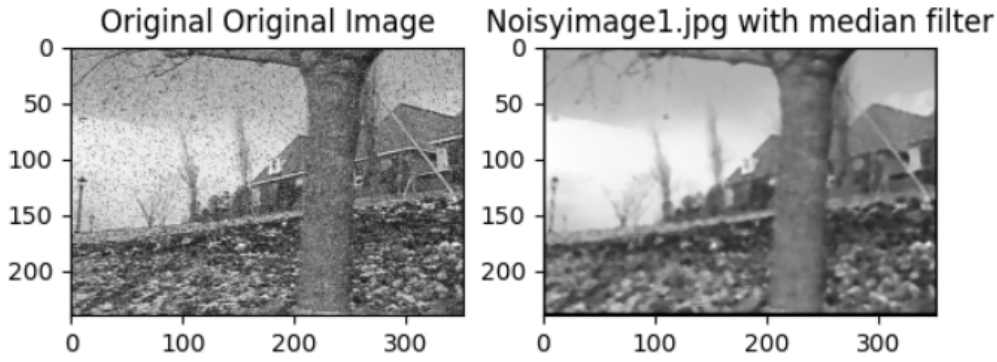

Figure 28. Noisy Image1 with Median Filter (5x5)

3.2.2 Noisy Image 2

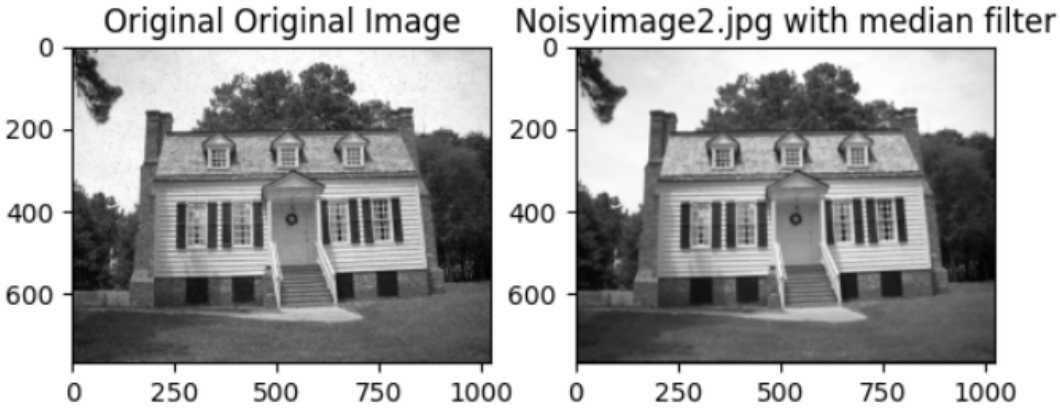

Figure 29. Noisy Image2 with Median Filter (5x5)

This picture seems to have isolated bright and dark pixels making up salt-and-pepper noise. Because the averaging filter may end up incorporating the outlier values into the average, increasing the visibility of the noise, it may be inefficient against this kind of noise.

However, outliers have less of an impact on the median filter. It preserves borders and fine features by selecting values that are closer to the majority of surrounding pixels. This explains why, in comparison to the filtered picture using the averaging filter, the one using the median filter seems sharper and has more distinct edges.

4 Q4

4.1 Gradient Magnitude

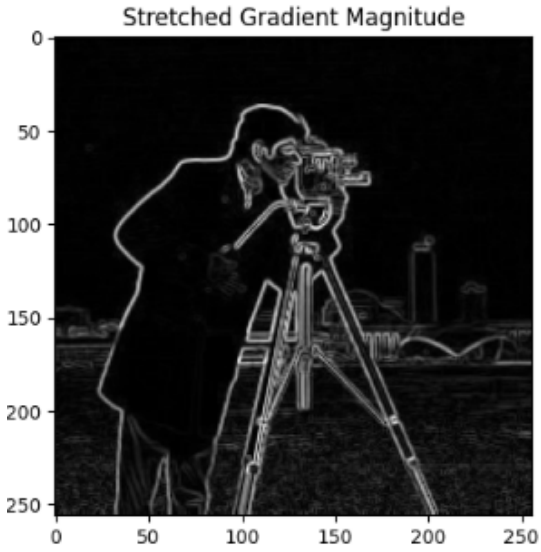

Figure 30. Gradient Magnitude for Q_4 image

The gradient magnitude image displays the strength of the image's edges. Greater contrast between darker and brighter sections denotes smoother regions with less variation in brightness.

As we can see:

- **Bright edges surrounding the person:** With high magnitude values, the person's outline is apparent, particularly around the chest, arms, and legs. This draws attention to how starkly the figure stands out against the surroundings.
- **Weaker edges within the person:** The clothes and hair have lower magnitude values, indicating softer brightness transitions in these areas.
- **A gradual decrease in magnitude towards the background:** The bottom portion of the image exhibits the least amount of brightness variations, while the edges grow less and less distinct.

4.2 Histogram of Gradient Magnitude

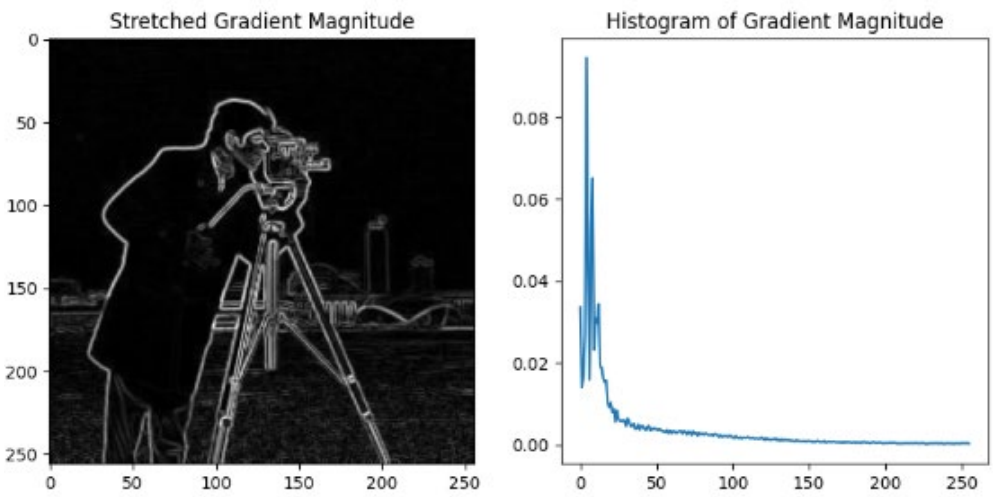

Figure 31. Histogram of Gradient Magnitude for Q_4 image

A statistical distribution of the gradient magnitude values over the whole picture is provided by the histogram. The number of pixels with a certain magnitude value is shown by each bar.

We can note:

- **A noticeable peak at lower magnitude values:** This suggests that smooth areas with gentle brightness variations make up a significant amount of the image.
- **A secondary peak with a greater magnitude:** This is consistent with the robust boundaries surrounding the subject's body, indicating the existence of notable brightness differences.
- **A long tail towards the right side of the histogram:** indicates a few isolated pixels with extremely high magnitude values, which might be noise or extremely sharp edges.

4.3 Gradient Orientation

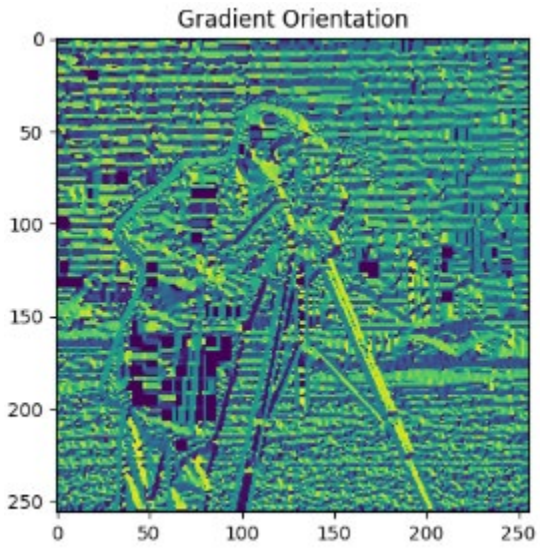

Figure 32. Gradient Orientation for Q_4 image

The gradient orientation image uses colored arrows to indicate the direction of the picture's edges. The arrow's color is correlated with the edge's angle; for example, red and orange denote horizontal edges, green and blue indicate vertical edges, while yellow and purple indicate diagonal edges.

We can note:

- **Dominant vertical edges:** Take note of the profusion of blue and green arrows, especially surrounding the subject's torso and legs. This implies that the body's form is defined by strong vertical lines.
- **The limbs' diagonal edges** are shown by the yellow and purple arrows that encircle the arms and legs. These most likely match the limbs' shapes.
- **Horizontal ground edges**: A few red and orange arrows may be seen close to the image's bottom, indicating the presence of horizontal ground edges.

4.4 Histogram of Gradient Orientation

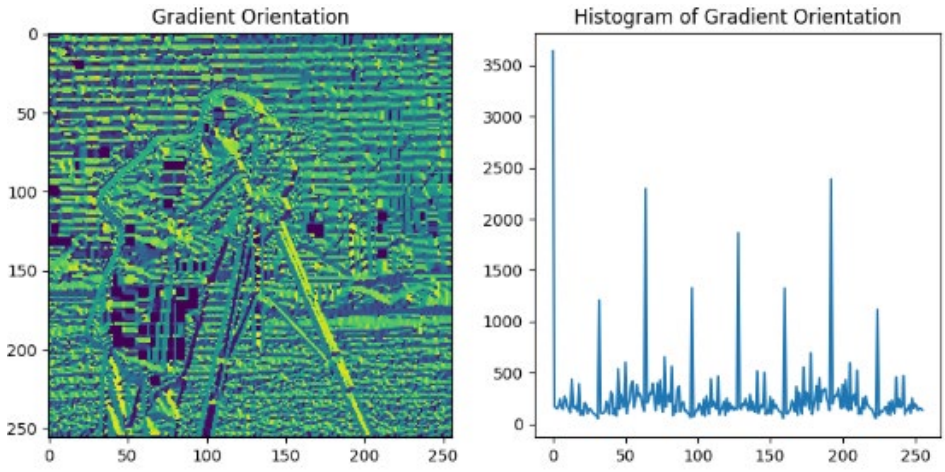

Figure 33. Histogram of Gradient Orientation for Q_4 image

The distribution of edge orientations over the whole picture is displayed via the histogram. A certain edge angle's frequency is shown by each bar.

We can observe:

- **Peaks at 0 and 180 degrees:** They line up with the main vertical lines seen in the gradient orientation image and represent vertical edges.
- **The horizontal edges**, which are also present but less often than the vertical ones, are shown by the smaller peaks at 90 and 270 degrees.
- **Diagonal edges** are shown by smaller peaks at 45 and 135 degrees, which further supports the existence of diagonal contours in the limbs.

5 Q5

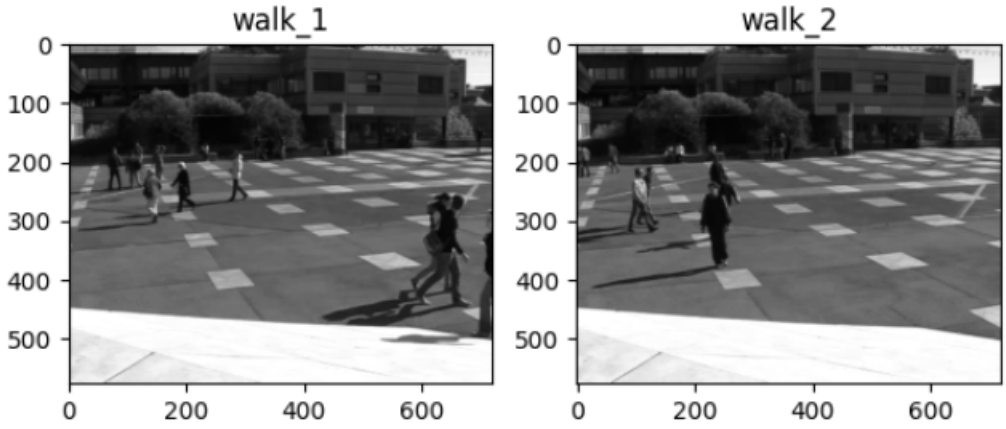

Figure 34. Original images (walk1 and walk2)

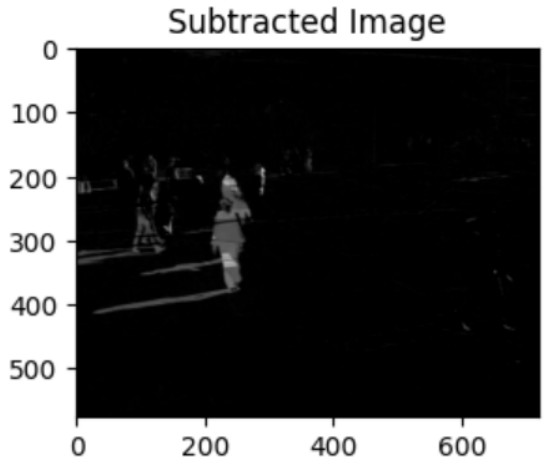

Figure 35. Subtracted Image

A new grayscale image demonstrating the variation in intensity between the relevant pixels in the two original photos would be the outcome of this subtraction. For instance, the resultant pixel in the difference image would be white if a pixel in walk_1.jpg is much brighter than the comparable pixel in walk_2.jpg. On the other hand, the resultant pixel in the difference image would be black if a pixel in walk_1.jpg is less bright than the comparable pixel in walk_1.jpg.

6 Q6

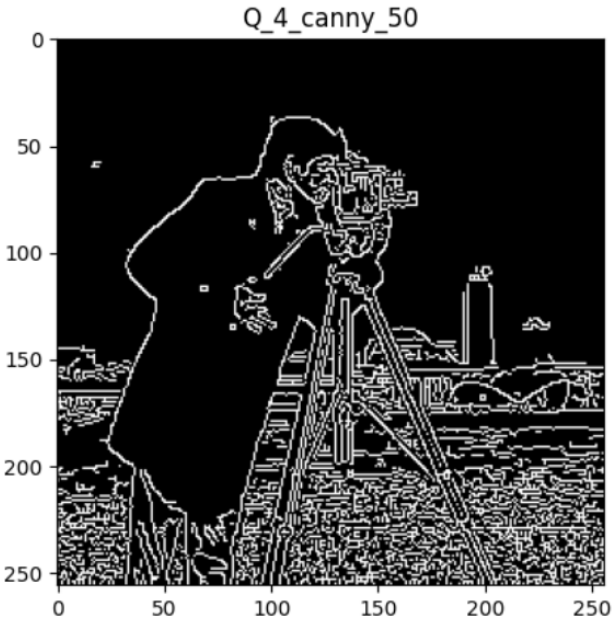

Figure 36. Q_4 Image with Canny threshold = 50

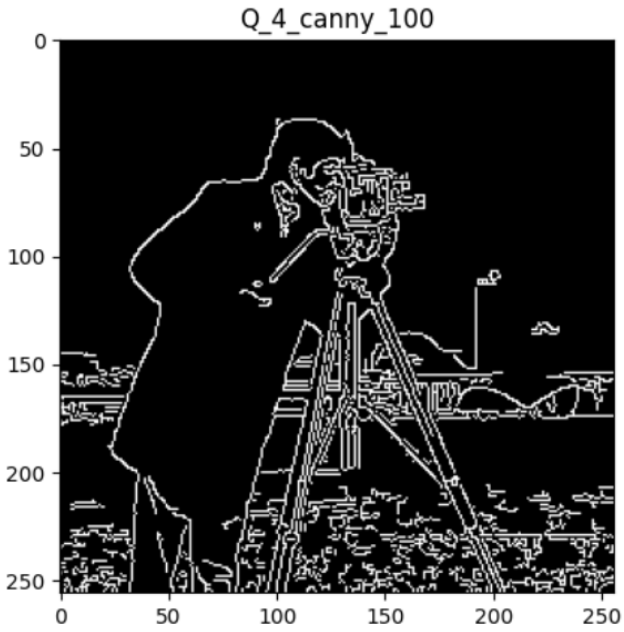

Figure 37. Q_4 Image with Canny threshold = 100

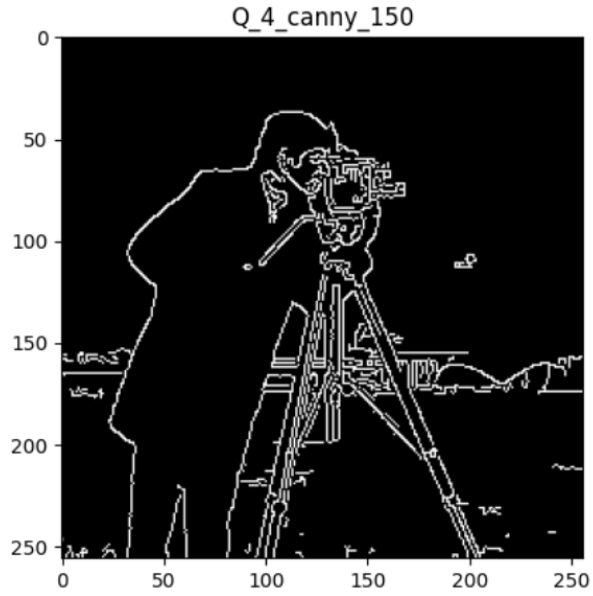

Figure 38. Q_4 Image with Canny threshold = 150

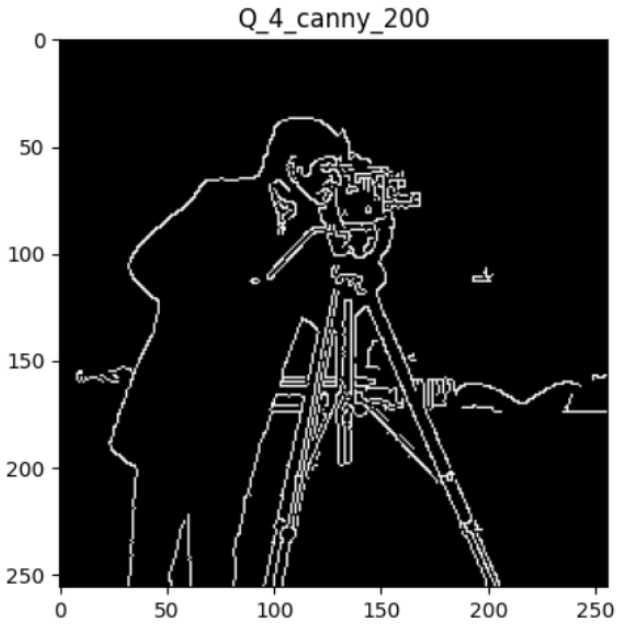

Figure 39. Q_4 Image with Canny threshold = 200

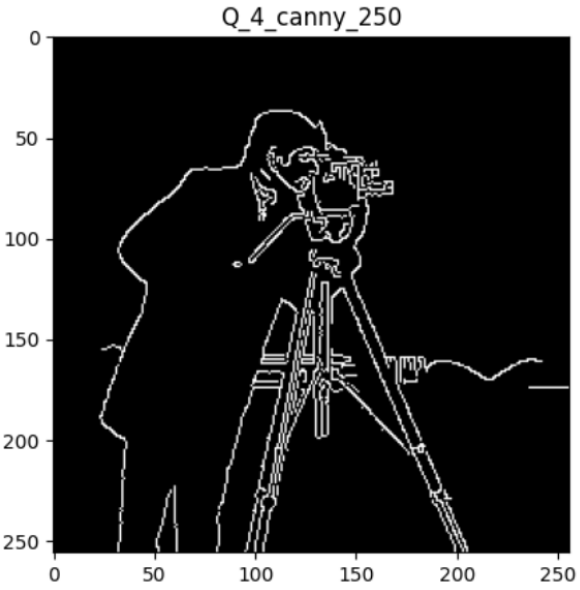

Figure 40. Q_4 Image with Canny threshold = 250

Threshold 50: Since it is the most sensitive arrangement, even minute variations in intensity will be detected as edges. This can result in a jumbled picture with lots of fine lines, noise, and unimportant edges as shown in Figure 36.

Thresholds 100, 150: This level will remove noise and weaker edges in comparison to 50, giving you a more focused and organized edge map.

It's possible to overlook certain subtle edges, particularly in low-contrast areas.

Threshold 200: With a greater emphasis on distinct and robust edges, this threshold becomes even more selective. It's possible to lose all fine details and moderately contrasted edges.

As seen in Figure 38, this option was used to draw attention to the primary curves and forms of the things in the picture.

Threshold 250: Only the most prominent and significant edges will remain.

Many important edges might be missing, making it difficult to fully understand the image content.

7 How to run the code

I've included a Google Colab file called "Assign1" that has the plots and photos for every question, along with the code.