# E9 241 Digital Image Processing
# Assignment 04 Report

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**Discipline:** Signal Processing

**Department:** Electrical Engineering

## Q1. Image Denoising:

### Observations/Results:

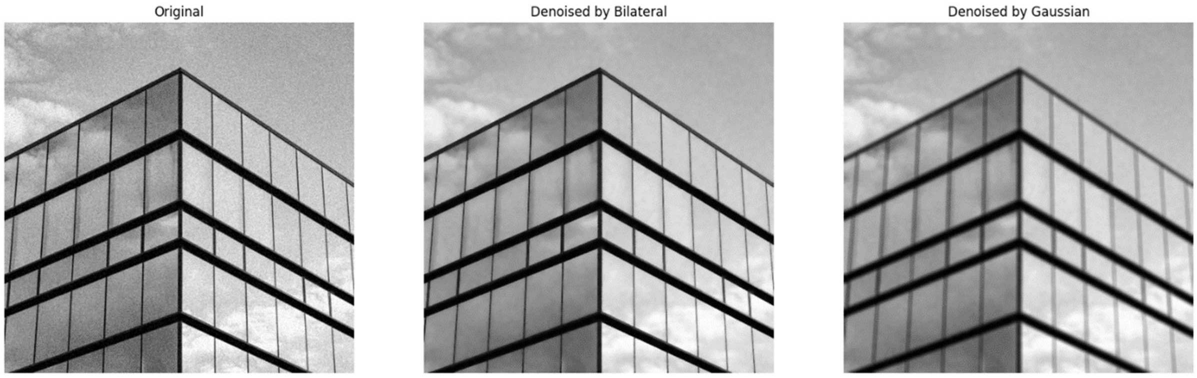


Figure 1

Figure 1 shows the original noisy image (Left) with the denoised images (Centre – Denoised by Bilateral Filter, Right – Denoised by Gaussian Filter)

The hyper-parameters chosen are $K_g = 1$, $K_h = 1$, $\sigma_h = 50$, $\sigma_g = 100$.

Both the denoising methods reduce noise to a certain amount but it can be observed that the edges in the Bilateral Filtered Image is more prominent than the ones in the Gaussian Filtered Image.

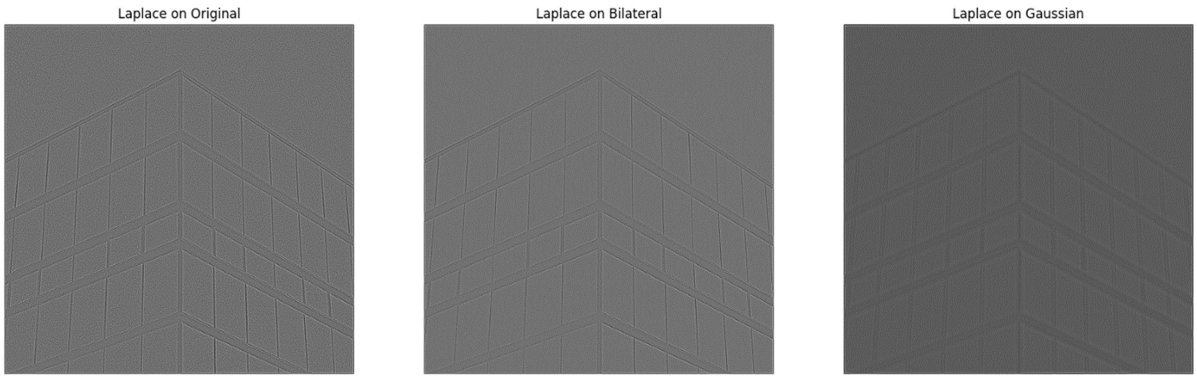


Figure 2

Figure 2 shows the Laplace Filtered Images (Left – On Original Image, Centre – On Bilateral Filtered Image, Right – On Gaussian Filtered Image)

In Laplacian Filtering, smooth regions are given by gray (~125) and change in intensity is given by low(~0) or high (~255) values(depending on the direction of transition)

From the Laplacian filtered Images, it can be seen that the noise in the first image is accurately represented in case of the original image (contains lots of Blacks and whites) This occurs since, noise is nothing but sudden change in intensity. In the denoised images, noise is reduced.

For the Bilateral Filtered Image, the edges can be observed to be sharp (single/('thin') straight lines of low(~0) or high (~255) values can be seen at the edges).

But for the Gaussian Filtered Image it can be observed that the edges are blurry. (multiple straight lines of mid values (giving the effect of fat edge) can be seen around edges which signifies blurry edges)

Comments/Inferences:

In Bilateral Filtering the edges are preserved while in Gaussian Filtering the edges get smoothened. This occurs since Gaussian does weighted averaging based on only spatial distance of surrounding pixels. In the case of Bilateral Filtering, in addition to spatial distance, luminance distance is also considered. So, similar intensity pixels have more weightage in the averaging rather than dissimilar intensities. This causes preservation of edges in Bilateral Filtering.

## Q2. Edge Detection:

### Observations/Results:

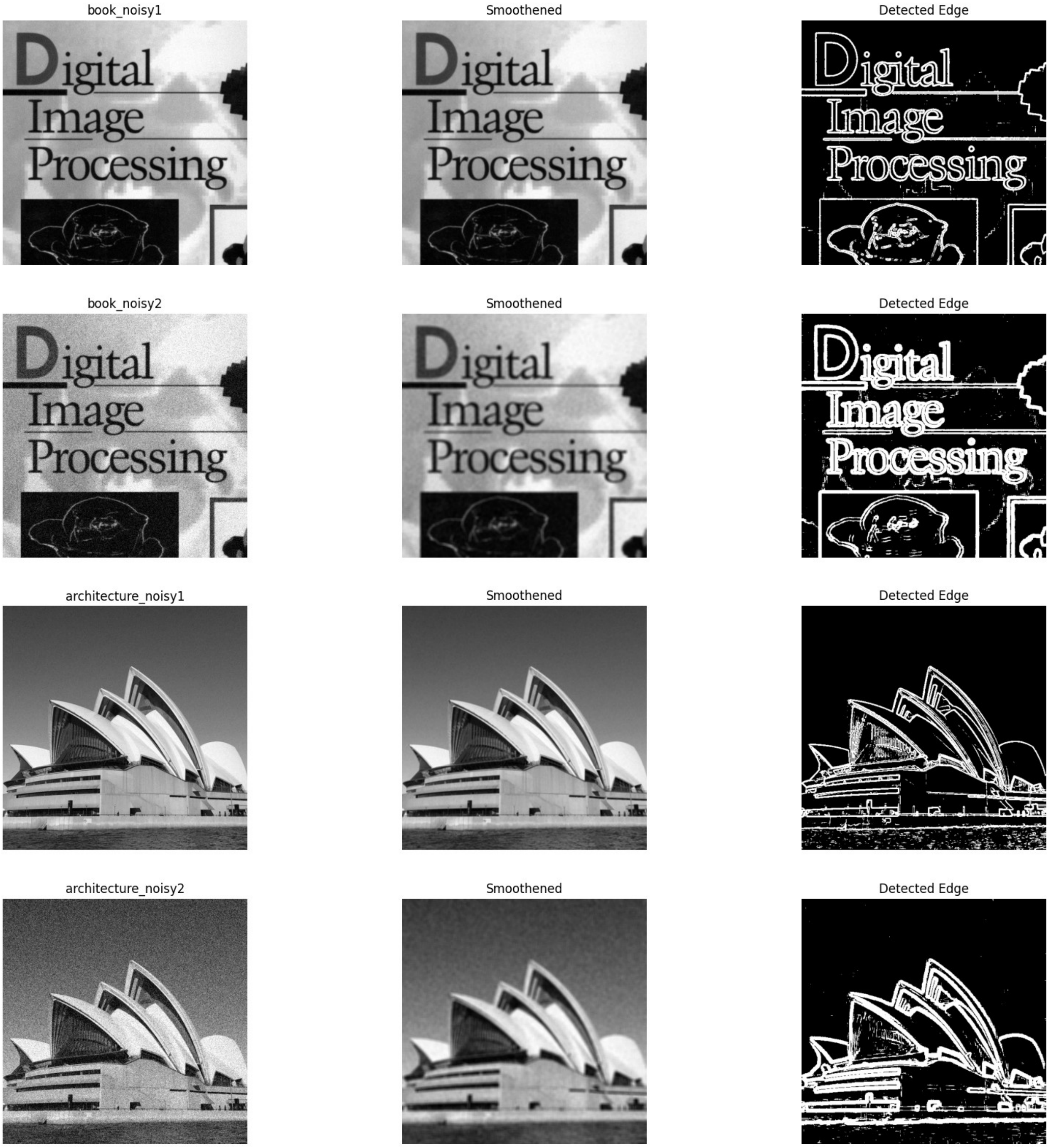


Figure 3

Figure 3 shows the noisy images, their smoothened versions and the edge map detected out of the smoothened versions.

The edge detection operator used for these images is 'Sobel Operator'.

For less noisy images ('noisy_1' images) gradient threshold is chosen as 30.

For more noisy images ('noisy_2' images) gradient threshold is chosen as 50.

**Comments/Inferences**:

Effect of Gaussian Smoothening (Threshold is kept constant):

- Gaussian Smoothening is **increased** (std deviation is increased)
    - Observation - Number of detected edges is reduced.
    - Reason – Increased Smoothening reduces intensity difference and the gradient magnitude decreases. This cause some edges to fall below the gradient threshold for edges. Hence, less edges are detected.
- Gaussian Smoothening is **reduced** (std deviation is decreased)
    - Observation - Number of detected edges is increased. More noise is detected as edges.
    - Reason – Since Smoothening is decreased so gradient magnitude at edges are less reduced. Hence, more edges are detected along with more noise detected as edges.

Effect of gradient threshold on the detected edges (Gaussian Smoothening is kept constant)

- Threshold is **increased**
    - Observation - Number of detected edges is reduced.
    - Reason – Less edges are there beyond the threshold. Less noise is detected as edges.
- Threshold is **reduced**
    - Observation - Number of detected edges is increased. Noise is also detected as edges.
    - Reason – More edges are present beyond the threshold. Even some noise which are detected due to performing gradient on the image are also present beyond the threshold. So, more noise is detected as edges.

## Q3. Image Deblurring:

### Observations/Results:

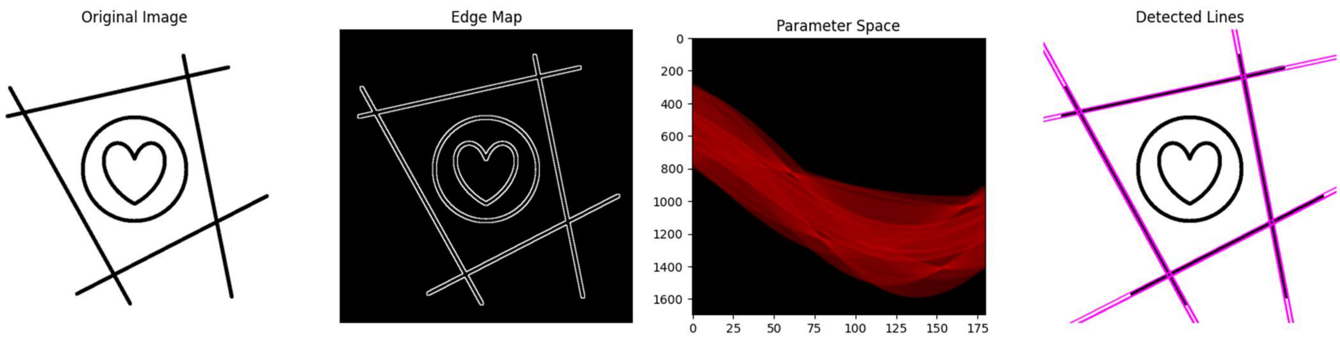


Figure 4

Figure 4 shows the Synthetic Image, The Edge Map of the Image, the Parameter Space from Hough Transform of the Image, The Detected Lines from the Image.

In Figure 4 the resolution bin for **θ** is chosen as **1°** and the resolution bin for **d** is chosen as 1 pixel.

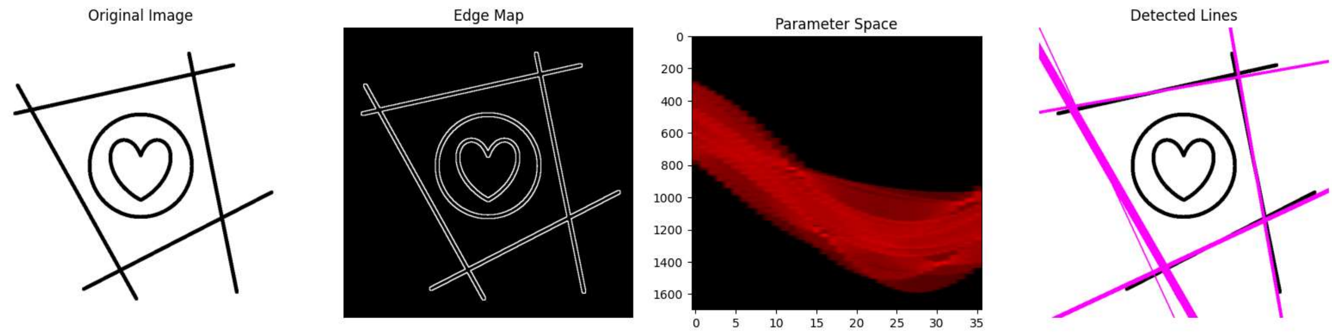


Figure 5

In Figure 5 the resolution bin for **θ** is increased to **5°.** Results in coarser approximation of the lines.

### Synthetic Image Affected by Noise:

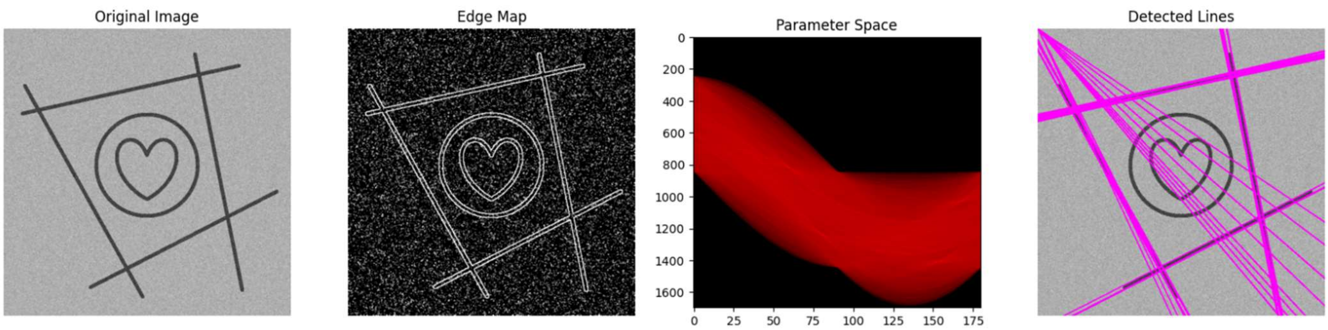


Figure 6

In Figure 6 , Hough Transform is applied on a noisy version of the synthetic image. Noise appears on the edge map which causes some stray to appear on the Detected Lines image.

This occurs since, some noise points line up to create those stray lines.

**Synthetic Image Affected by Occlusion:**

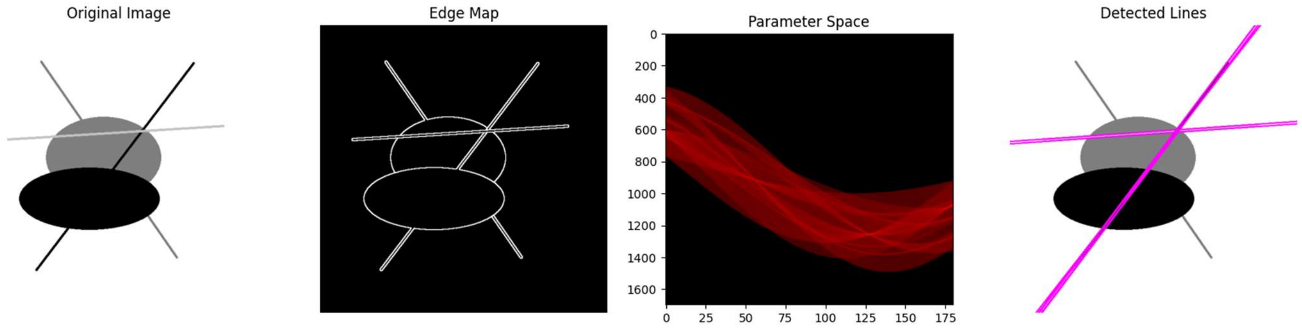


Figure 7

In Figure 7 Hough Transform is applied on a Synthetic Image Affected by Occlusion. It can be seen that one line is not detected due to occlusion.

**Real Images:**

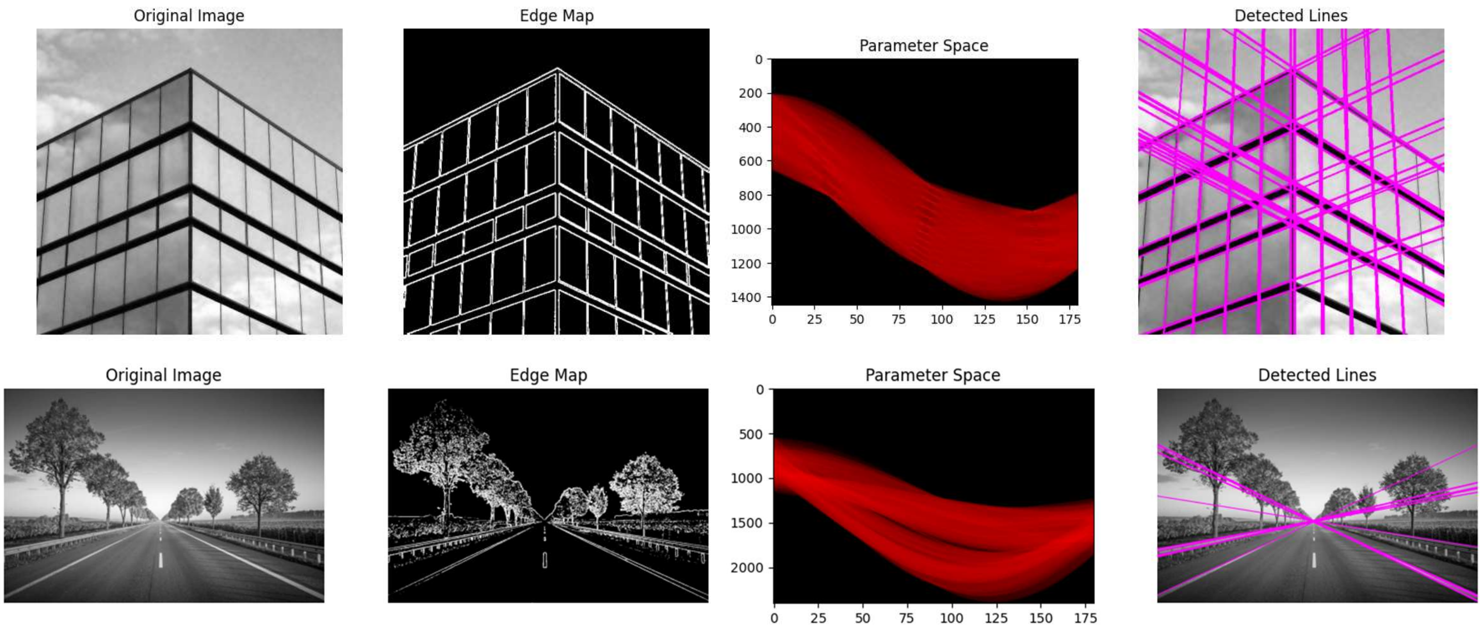


Figure 8

In Figure 8, the Hough Transform is applied on real images and the Detected Lines are shown.

**Comments/Inferences:**

From the above results we can see that Hough Transform algorithm for Lines can only detect lines and no other shapes. To detect other shapes, different Hough Transform algorithms are required.

In the Noisy Synthetic Image and Occlusion Affected Image, better detection is possible by varying the Accumulator threshold of the Hough Transform.

In real images, line detection is also dependent on the quality of the edge detection. Better edge detection will lead to better line detection.