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Lab 3. Noise Filtering in Images

1. Adding Salt-and-Pepper Noise

Salt-and-pepper noise was added to the selected image at three different noise levels: 3%, 5%, and 15%.
This type of noise appears as random black and white pixels and is considered impulsive noise.

2. Applying Noise-Reducing Filters

Three different filters were applied to reduce the noise:

- Median Filter with window sizes 3×3, 5×5, and 7×7
- Gaussian Filter
- Bilateral Filter

3. Adding Gaussian Noise

Gaussian noise was added at three levels: 5%, 10%, and 15%.
This noise creates random variations in brightness and is considered smooth, continuous noise.

4. Filtering Gaussian Noise

The same three filters were used to reduce Gaussian noise.

5. Image Display

The following were displayed:

- The original image
- The noisy images
- The filtered images
- PSNR values for each filtering result

Analysis and Results

First: Analysis of Salt-and-Pepper Noise Reduction

PSNR Values Obtained:

3% Noise → Median: 32.25, Gaussian: 30.09, Bilateral: 30.64

5% Noise → Median: 31.25, Gaussian: 29.56, Bilateral: 30.54

15% Noise → Median: 30.84, Gaussian: 28.44, Bilateral: 29.77

Conclusion

- The Median Filter consistently performed the best in all salt-and-pepper noise cases. This is because the median filter replaces each pixel with the median of its neighborhood, effectively removing impulsive noise.
- The Gaussian filter was not very effective, as smoothing does not remove extreme pixel values.
- The Bilateral filter performed moderately well, preserving edges but not removing all impulse noise.

Important Note

- Higher noise levels required larger window sizes (5×5 and 7×7), but larger windows also increased image blurring.

Second: Analysis of Gaussian Noise Reduction

- PSNR Values Obtained:

5% Noise → Median: 31.87, Gaussian: 31.55, Bilateral: 30.74

10% Noise → Median: 30.83, Gaussian: 31.26, Bilateral: 30.72

15% Noise → Median: 30.47, Gaussian: 30.86, Bilateral: 30.66

Conclusion

- The Gaussian filter was generally the most effective for Gaussian noise. It is inherently designed to reduce smooth and dispersed noise.
- The Median filter gives acceptable results but may distort fine details.
- The Bilateral filter preserved edges well but did not achieve the highest PSNR.

Qualitative Analysis

1.Median Filter

- Best for salt-and-pepper noise
- Completely removes extreme values
- Larger kernels increase blurring

2.Gaussian Filter

- Best for Gaussian noise
- Smooths random variations effectively
- Can create edge blurring

3.Bilateral Filter

- Preserves edges very well

- Suitable for low to moderate noise
- Not always the highest PSNR

4.PSNR Interpretation

- Higher PSNR → better image quality
- Median achieved highest PSNR for salt-and-pepper
- Gaussian achieved highest PSNR for Gaussian noise

Final Conclusion

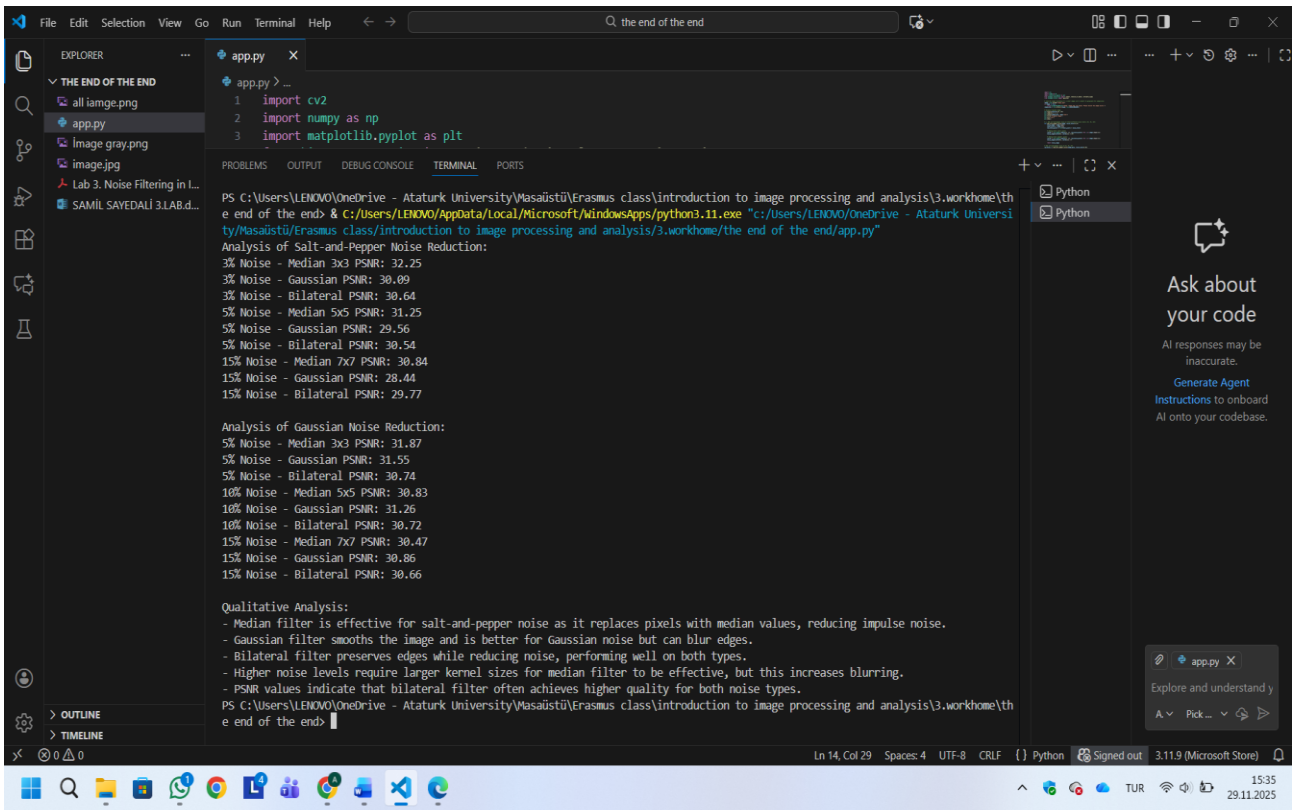
1. For salt-and-pepper noise → Median filter is the best choice.
2. For Gaussian noise → Gaussian filter provides the best results.
3. Bilateral filter is useful when we need a balance between noise removal and edge preservation.
4. Higher noise levels require larger kernel sizes → but this increases blurring.

Original picture

Gray Picture

All Picture

Results



Analysis of Salt-and-Pepper Noise Reduction:

3% Noise - Median 3x3 PSNR: 32.25

3% Noise - Gaussian PSNR: 30.09

3% Noise - Bilateral PSNR: 30.64

5% Noise - Gaussian PSNR: 29.56

5% Noise - Bilateral PSNR: 30.54

15% Noise - Median 7x7 PSNR: 30.84

15% Noise - Gaussian PSNR: 28.44

15% Noise - Bilateral PSNR: 29.77

Analysis of Gaussian Noise Reduction:

5% Noise - Median 3x3 PSNR: 31.87

5% Noise - Gaussian PSNR: 31.55

5% Noise - Bilateral PSNR: 30.74

10% Noise - Median 5x5 PSNR: 30.83

10% Noise - Gaussian PSNR: 31.26

10% Noise - Bilateral PSNR: 30.72

15% Noise - Median 7x7 PSNR: 30.47

15% Noise - Gaussian PSNR: 30.86

15% Noise - Bilateral PSNR: 30.66

Qualitative Analysis:

- Median filter is effective for salt-and-pepper noise as it replaces pixels with median values, reducing impulse noise.

- Gaussian filter smooths the image and is better for Gaussian noise but can blur edges.

- Bilateral filter preserves edges while reducing noise, performing well on both types.

- Higher noise levels require larger kernel sizes for median filter to be effective, but this increases blurring.

- PSNR values indicate that bilateral filter often achieves higher quality for both noise types.