MEDICAL IMAGING & DEEP LEARNING

# Low-Dose CT Image Denoising Using Poisson Noise and CNN

## Background

Computed Tomography (CT) uses X-rays to produce cross-sectional images of the human body.

## Aim

To investigate image denoising under low-dose CT conditions.



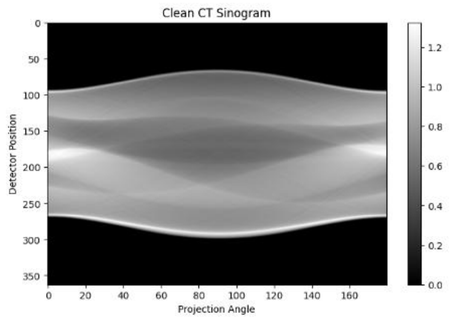
# Simulation and Methodology

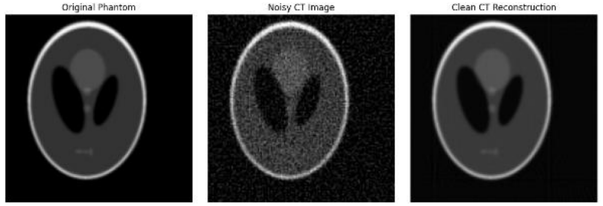
**Image generation:** 256 × 256 Shepp–Logan phantom reference image.

**Projection:** Radon transform generates CT projection sinogram.

**Noise simulation:** Poisson noise at three photon counts:

- **10,000** — higher photon count
- **3,000** — intermediate photon count
- **1,000** — lower photon count




**Original Phantom** → **Radon Transform** → **Poisson Noise Simulation** → **FBP Reconstruction** → **Denoising and Evaluation**

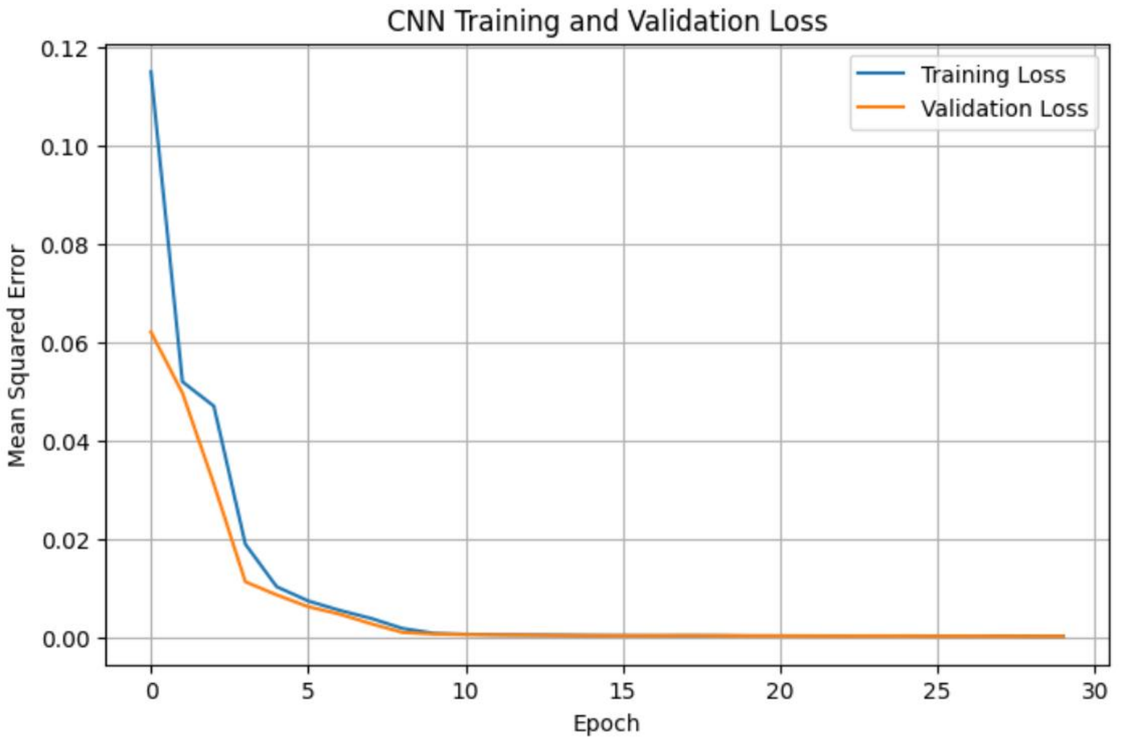
# Denoising Methods and CNN Training

### Classical Methods

- **Gaussian filter:** Smooths image noise.
- **Median filter:** Removes noise while preserving edges.
- **Bilateral filter:** Smooths noise while preserving boundaries.

### AI-Based Method (CNN)

- Trained on noisy and clean image pairs.
- Learns image features and noise patterns.
- Produces a denoised reconstructed image.

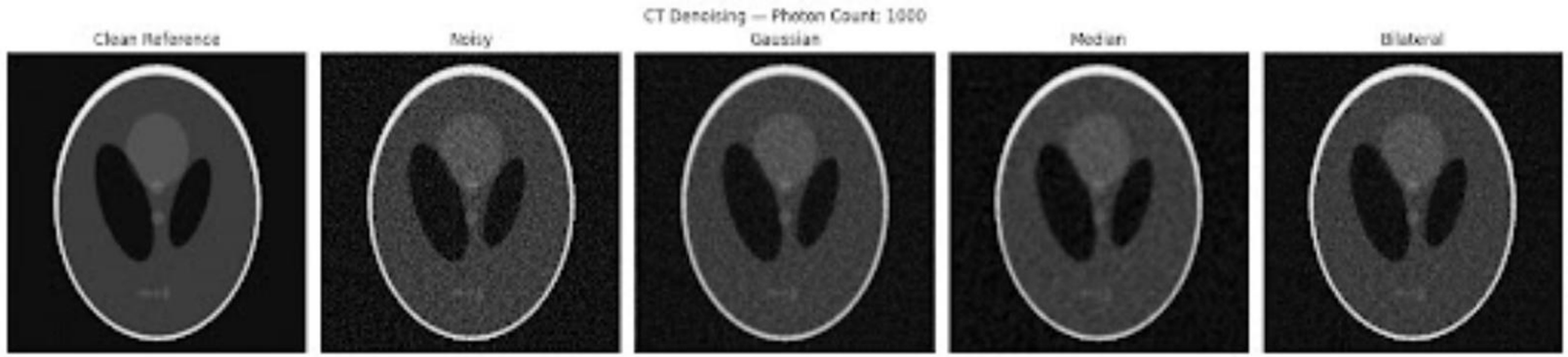


# Results and Quantitative Comparison

PART A

## Visual Comparison

Clean reference vs. noisy CT and classical filters.




PART B — METRIC 1

## PSNR (Peak Signal-to-Noise Ratio)

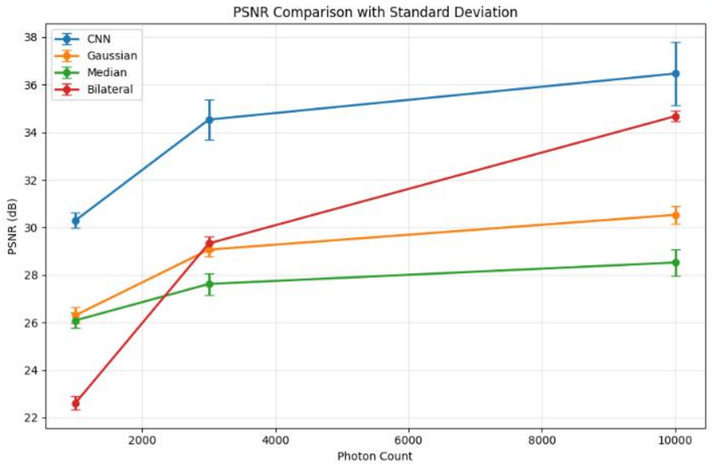
Measures reconstruction quality in decibels (dB). Higher values indicate less reconstruction error.

PART B — METRIC 2

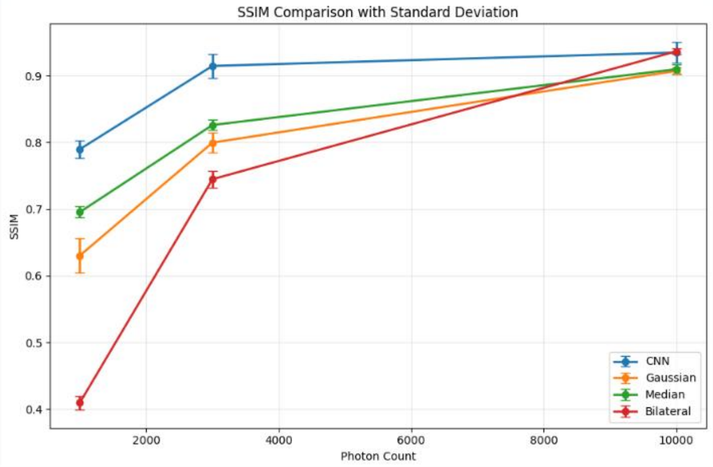
## SSIM (Structural Similarity Index)

Measures structural similarity to reference. Values closer to 1 indicate greater similarity.

# Quantitative Comparison: PSNR & SSIM




Highest PSNR across all photon counts.




Superior structural similarity (SSIM).

## Overall Average Performance

| Method | PSNR (dB) | SSIM |
|---|---|---|
| Noisy | 24.03 | 0.427 |
| Gaussian | 29.08 | 0.800 |
| Median | 27.70 | 0.828 |
| Bilateral | 29.28 | 0.743 |
| **CNN** | **34.58** | **0.917** |

# Key Findings, Limitations & Future Work

## Key Findings

- Lower photon counts produce noisier CT reconstructions.
- Classical filters improve quality to varying degrees.
- CNN achieves best overall average PSNR and SSIM.
- Deep learning shows strong promise for low-dose CT.

## Limitations

- Evaluation relies on simulated Shepp–Logan phantoms.
- Real clinical CT data not yet validated.
- Further testing needed for patient image generalization.

## Future Work

- Test trained CNN on public clinical CT datasets.
- Evaluate preservation of critical anatomical details.
- Investigate performance under realistic imaging conditions.