Use of Residuals in Image Denoising

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Why residual image

- In image denoising approaches done in the course we compared the denoised image with the original image. But in practice, we won’t have an original image.
- Hence, an estimate for the amount of noise in the image must be found out.

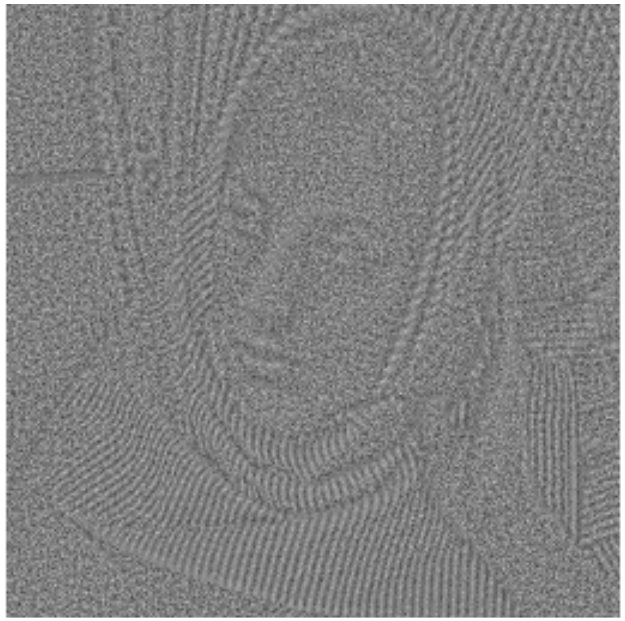
Residual image in brief.

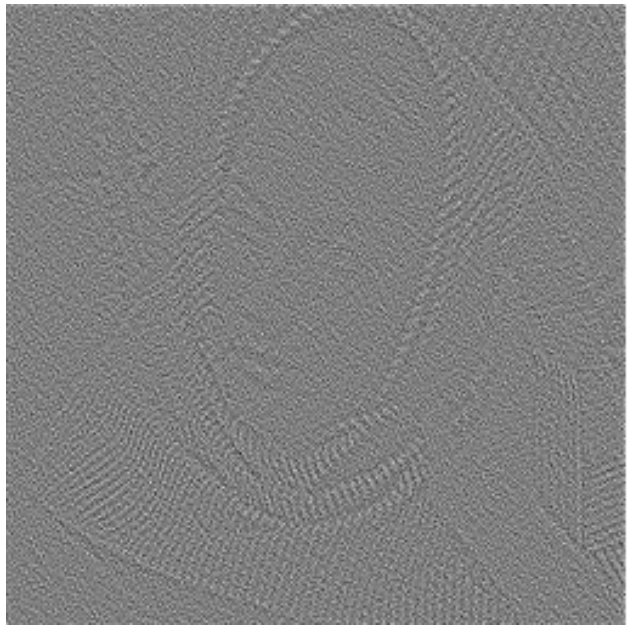
- If Y is the noisy image and D is the denoised version of the noisy image then Y-D is called the residual image.
- Intuitively, it would be an image containing all the noise and other components which were filtered out.

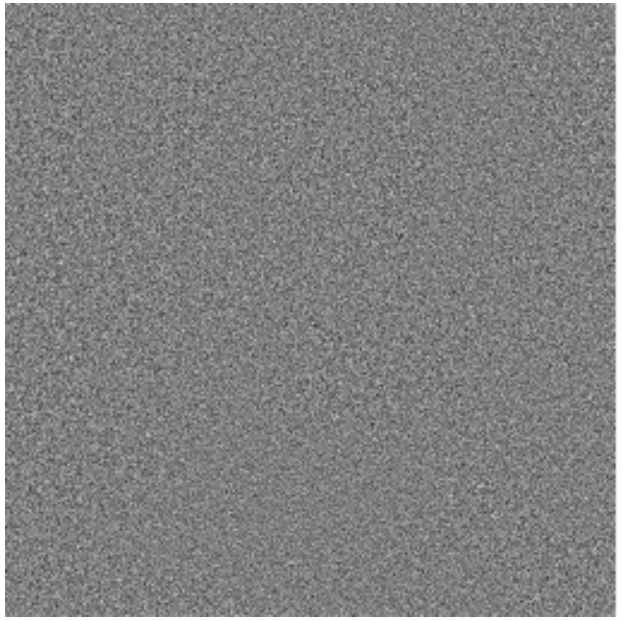
Properties used to find the estimate.

- As residual image is noisy, its autocorrelation should be close to 0.
- Also, if the filter filters out only the noise, then the residual image and the denoised image should be independent.
- Finally, its pdf should match the pdf of a Gaussian.

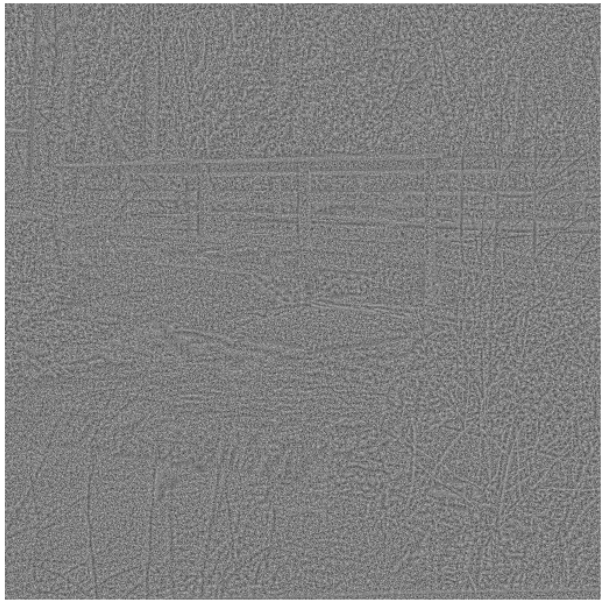
Residual Image

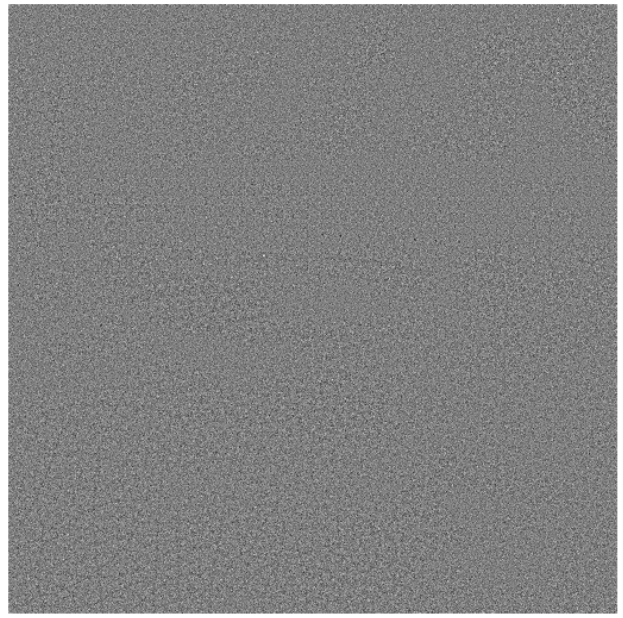






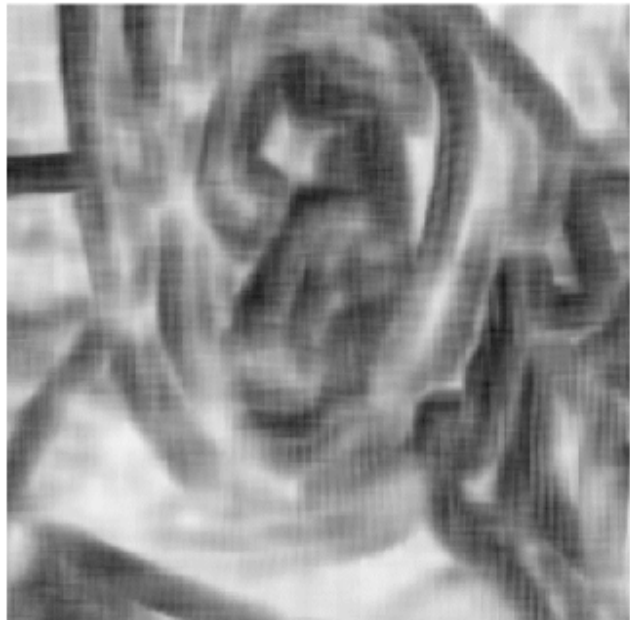
Residual image for output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Barbara).
Noisy appearance increases from L-R. Original image in top-right

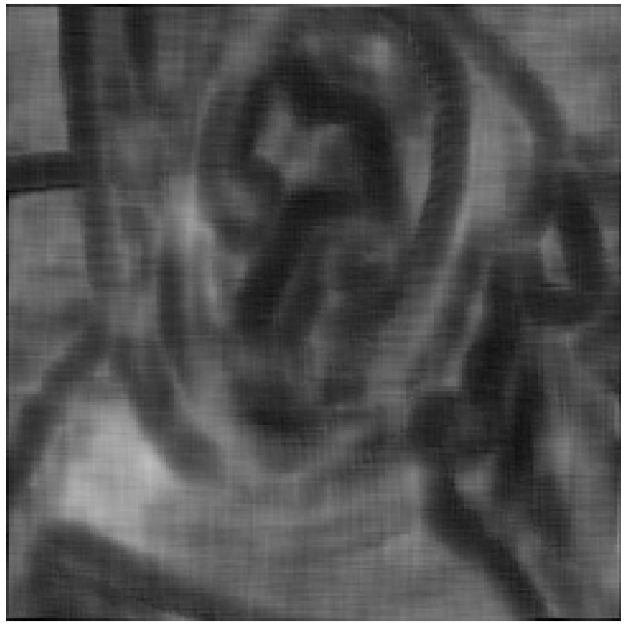


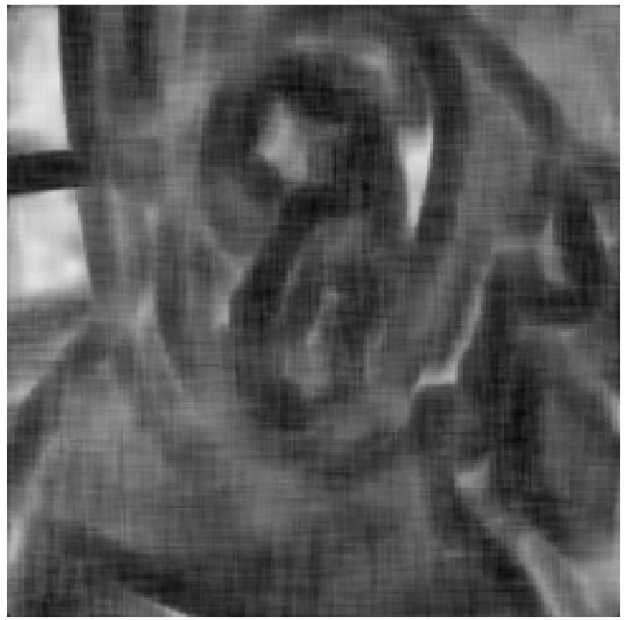


Residual image for output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Stream).
Noisy appearance increases from L-R. Original image in top-right

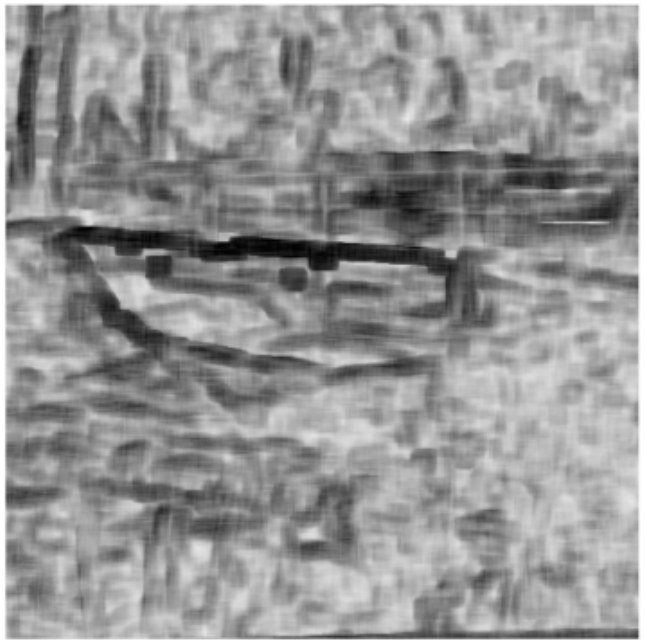
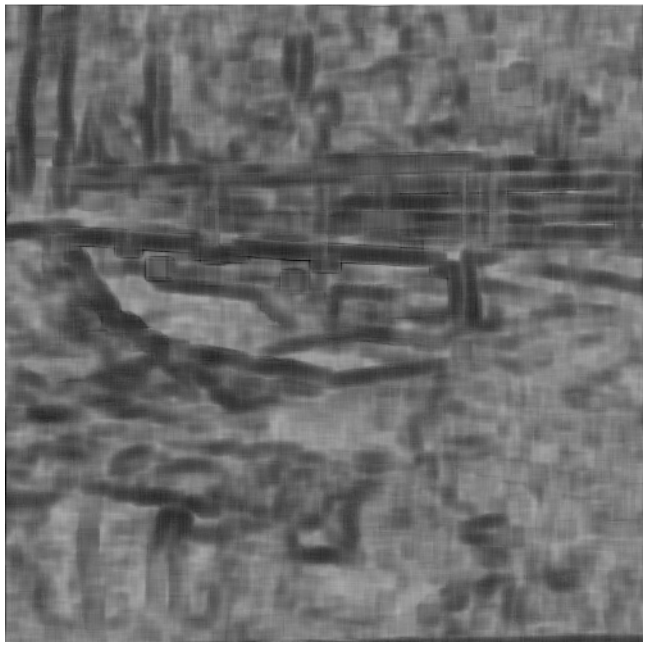
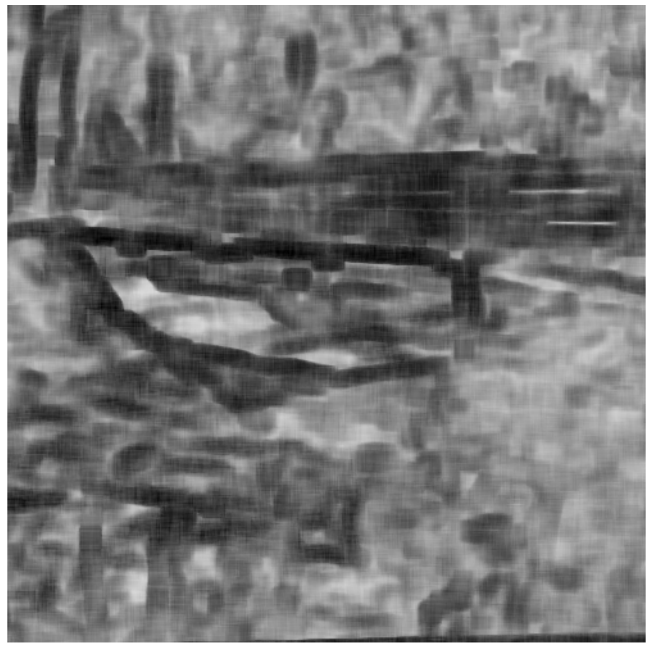
Pearson’s Correlation Coefficient Test





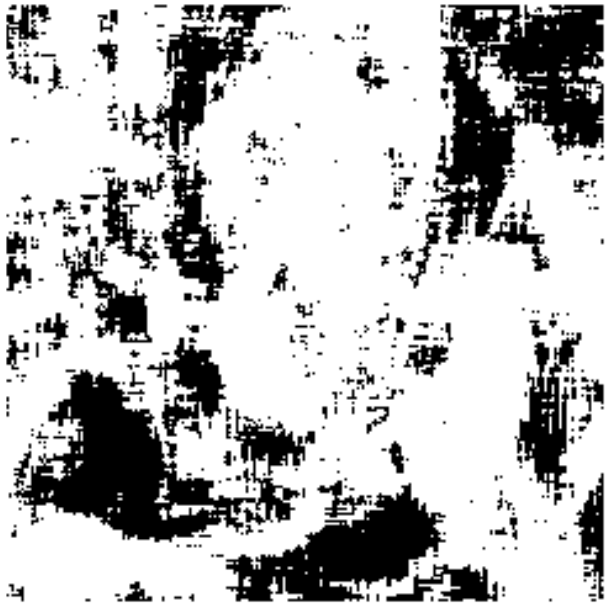


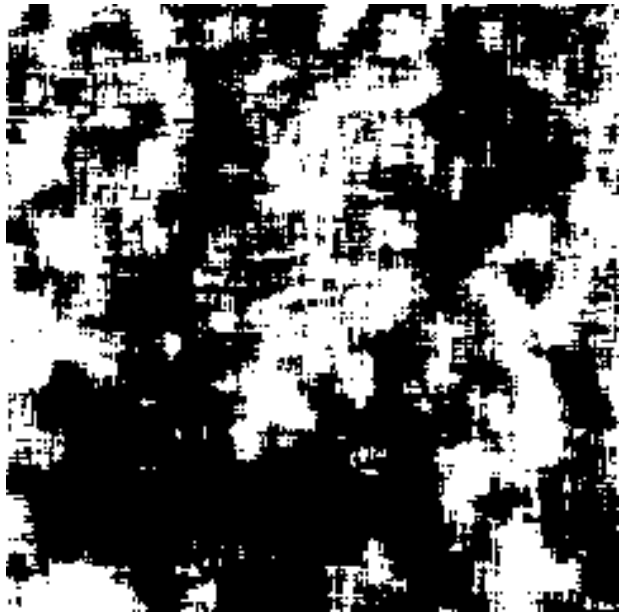
Pearson’s coefficient matrix obtained of output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Barbara)

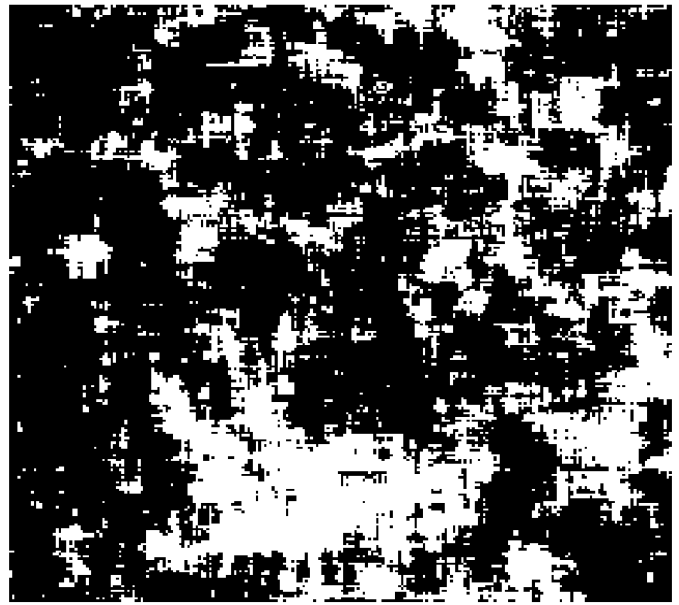




Pearson’s coefficient matrix obtained of output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Stream)

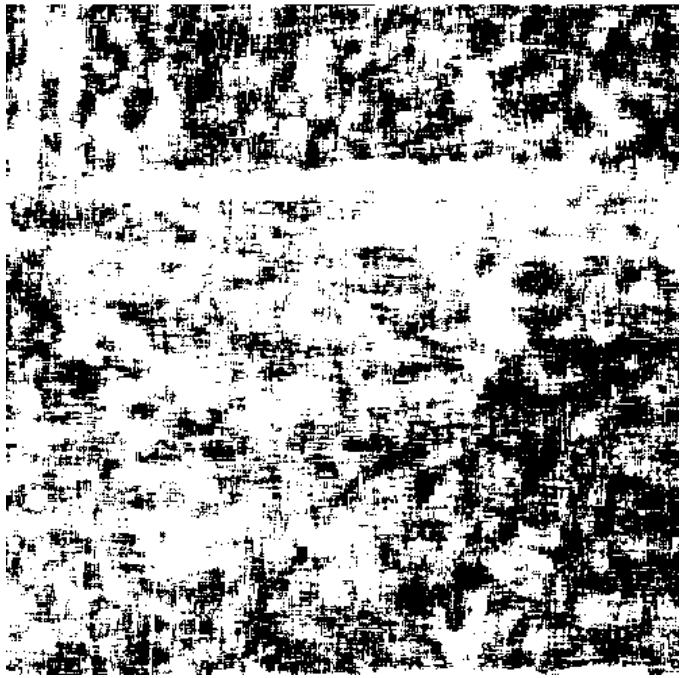
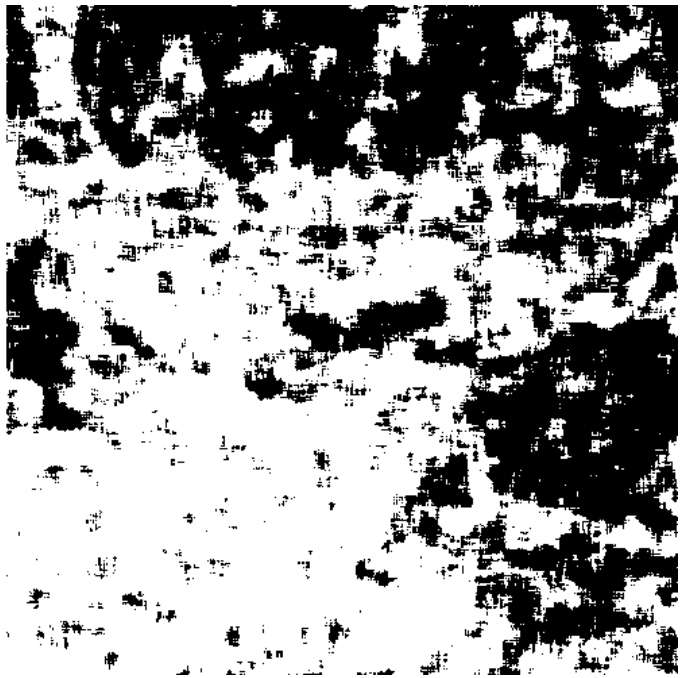
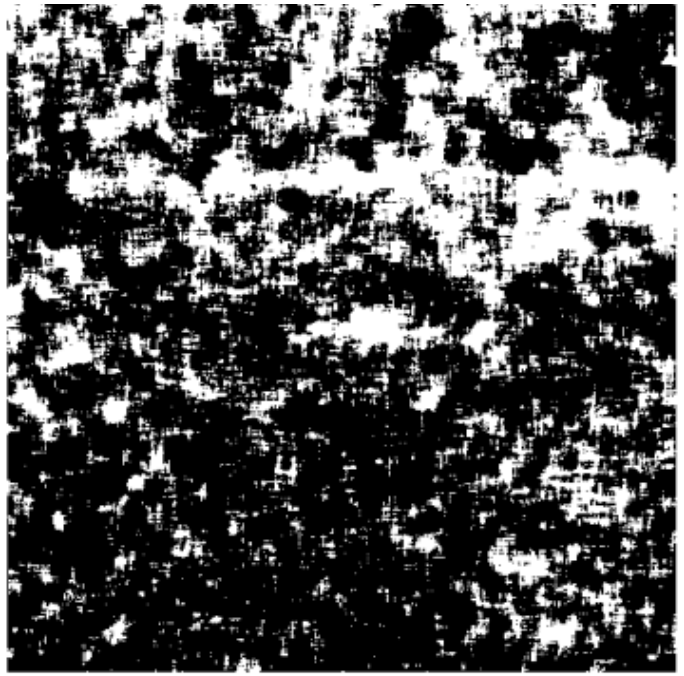
Kolmogorov-Smirnov (K-S) test for Normality





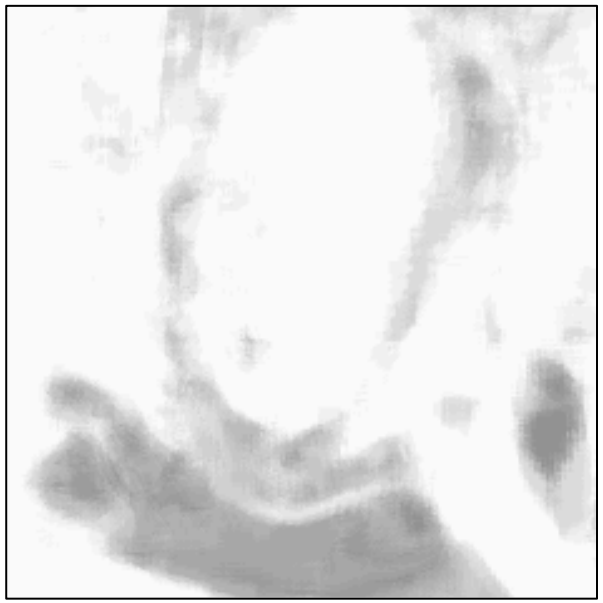
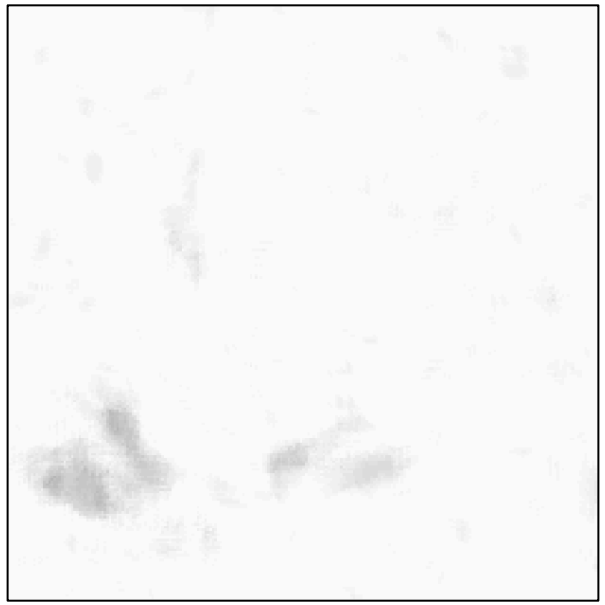
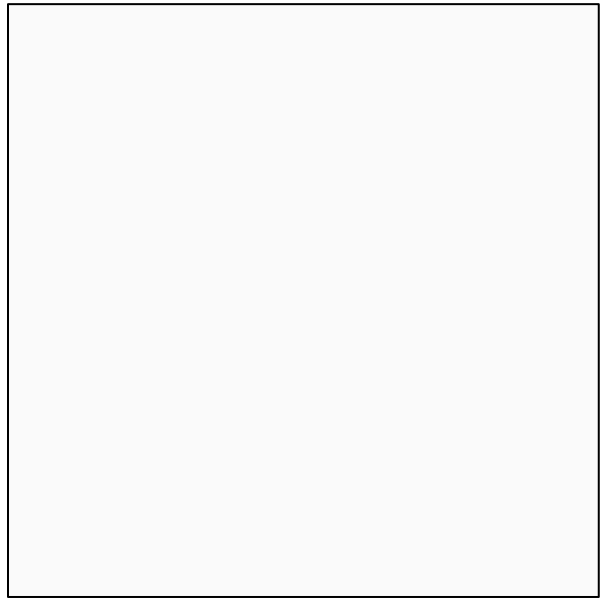


KS matrix obtained of output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Barbara)

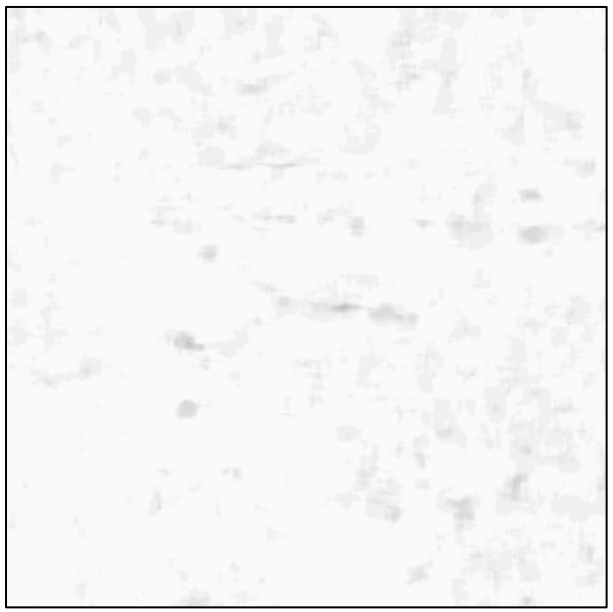




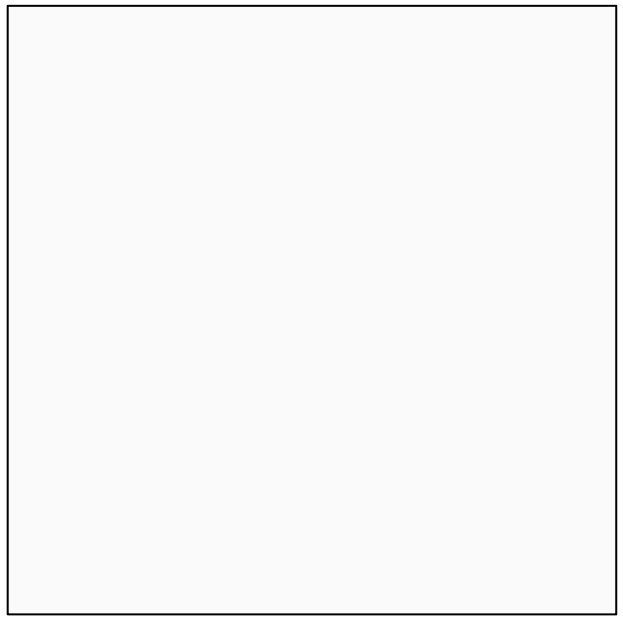
KS matrix obtained of output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Stream)

Autocorrelation

Autocorrelation matrix obtained of output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Barbara)





Autocorrelation matrix obtained of output of bilateral filter, weiner filter, adaptive weiner filter (L-R, Stream)

Peak to Signal Noise Ratio (PSNR)

- The parameters found in the previous slides were just qualitative.
- PSNR provides a quantitative estimate for the same.

Image	Bilateral Filtering	Weiner	Adaptive Weiner
Barbara	25.51	26.51	26.57
Stream	25.67	25.95	26.72

Obtained PSNR Values

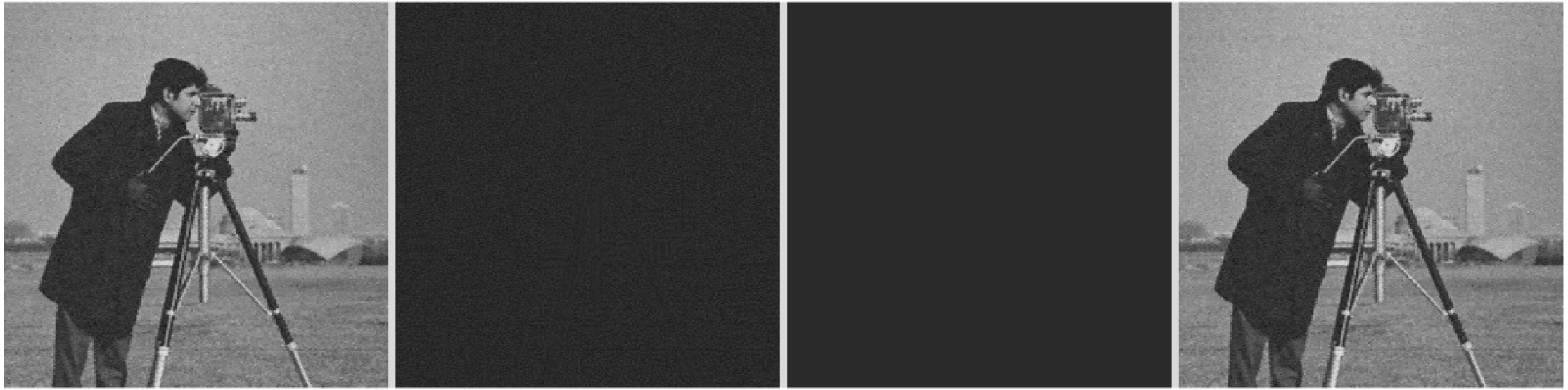
Denoising Algorithm Results

Original image, Noisy image (L-R, Cameraman)

Denoising Algorithm Results

First iteration of denoising process, Final denoised result chosen (L-R, Cameraman)

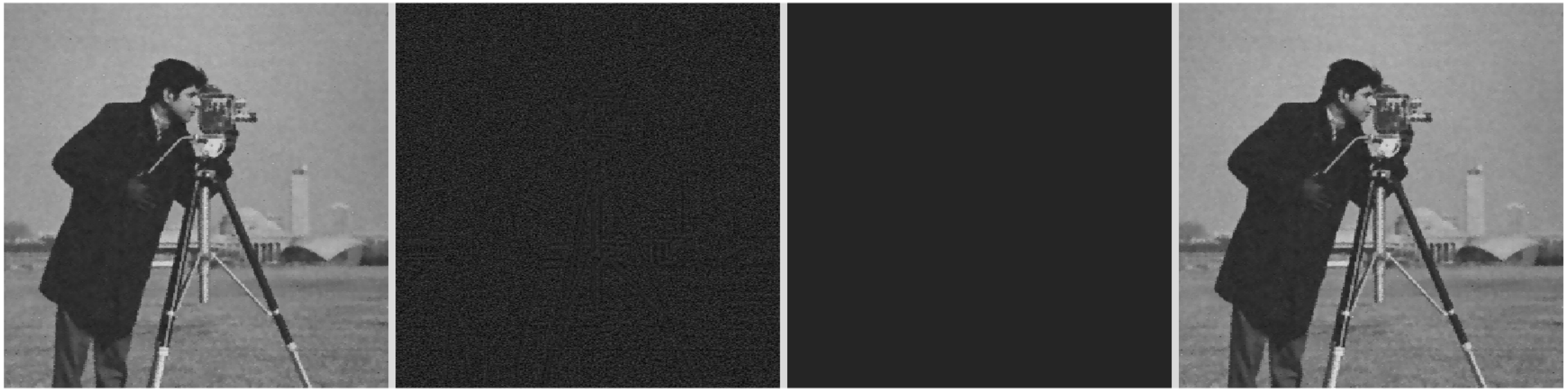
Denoising Process Iterations



Iteration 1

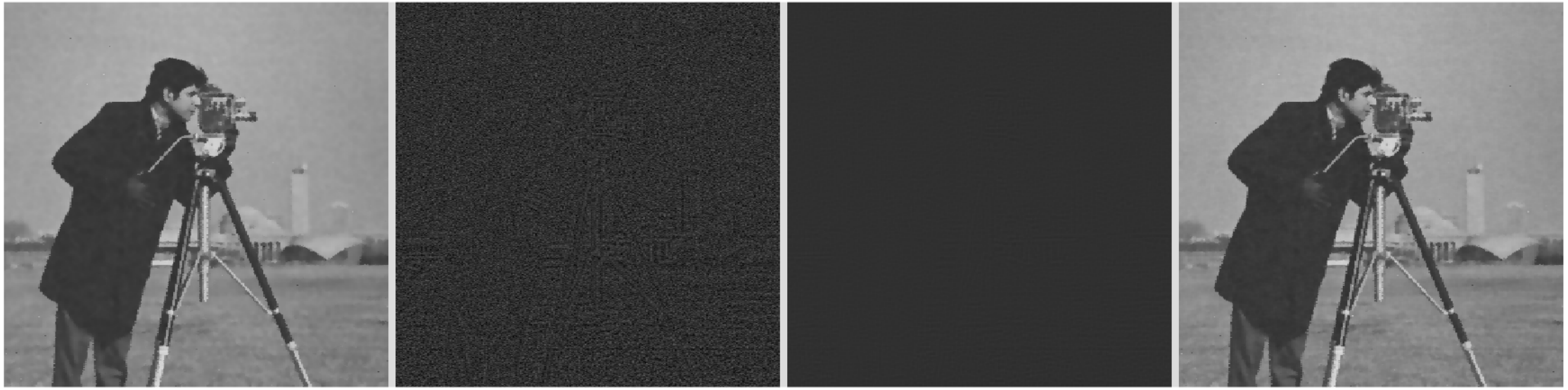
L-R: Denoised Image for the iteration, Residual, Denoised Residual, Sum of denoised residual and denoised image

Denoising Process Iterations



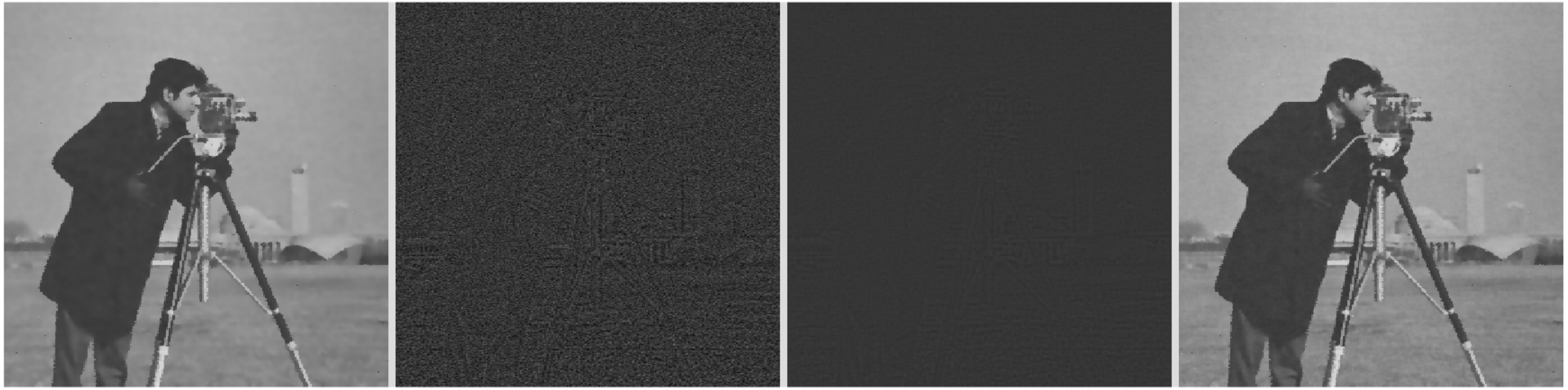
Iteration 2

Denoising Process Iterations



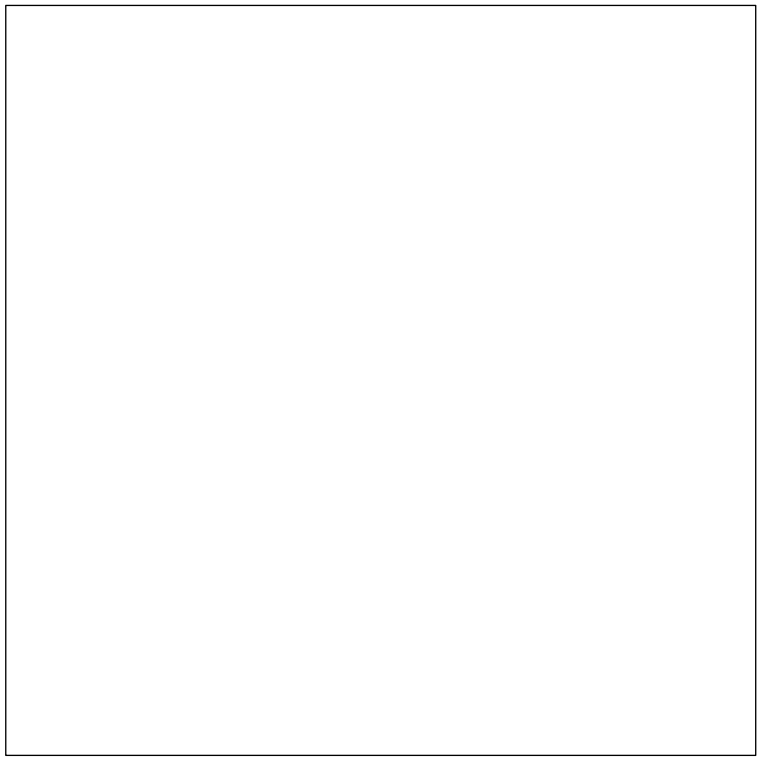
Iteration 3

Denoising Process Iterations



Iteration 4

K-S Normality test on different iterations



First iteration of denoising process (PSNR = 23.1), Second iteration (PSNR = 27.2) (L-R, Cameraman)

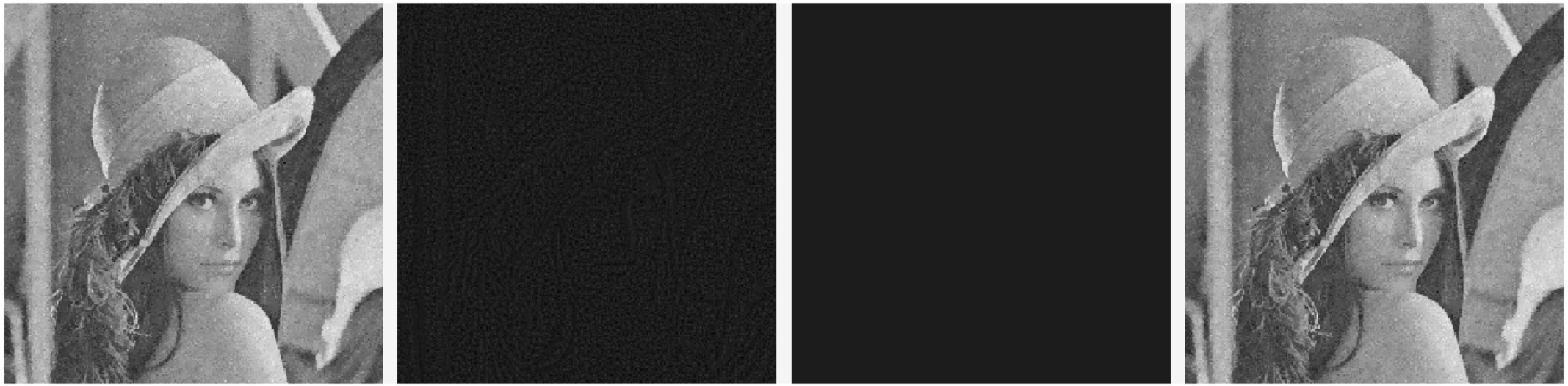
K-S Normality test on different iterations

Third iteration (highest PSNR = 43.8), Fourth iteration (PSNR = 33.3) (L-R, Cameraman)

Denoising Algorithm Results

Original image, Noisy image (L-R, Lena)

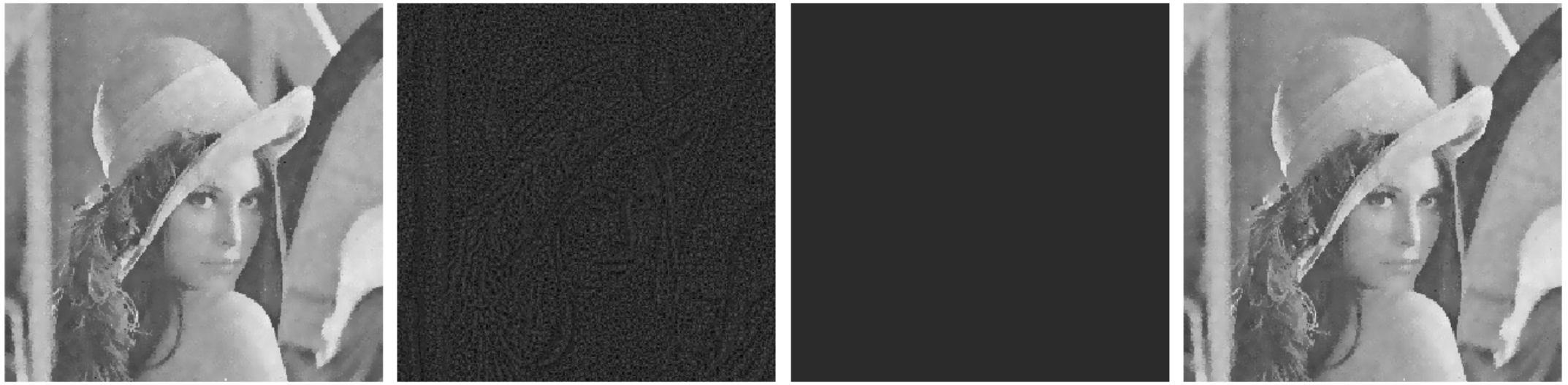
Denoising Process Iterations



Iteration 1

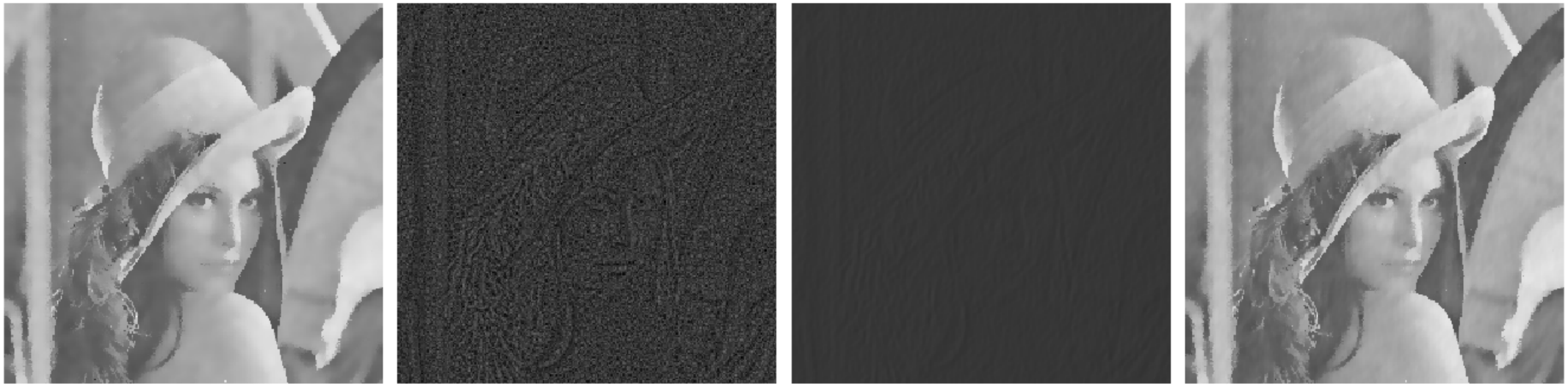
L-R: Denoised Image for the iteration, Residual, Denoised Residual, Sum of denoised residual and denoised image
Image Denoising: Bilateral Filtering, Residual Denoising: Wiener Filter

Denoising Process Iterations



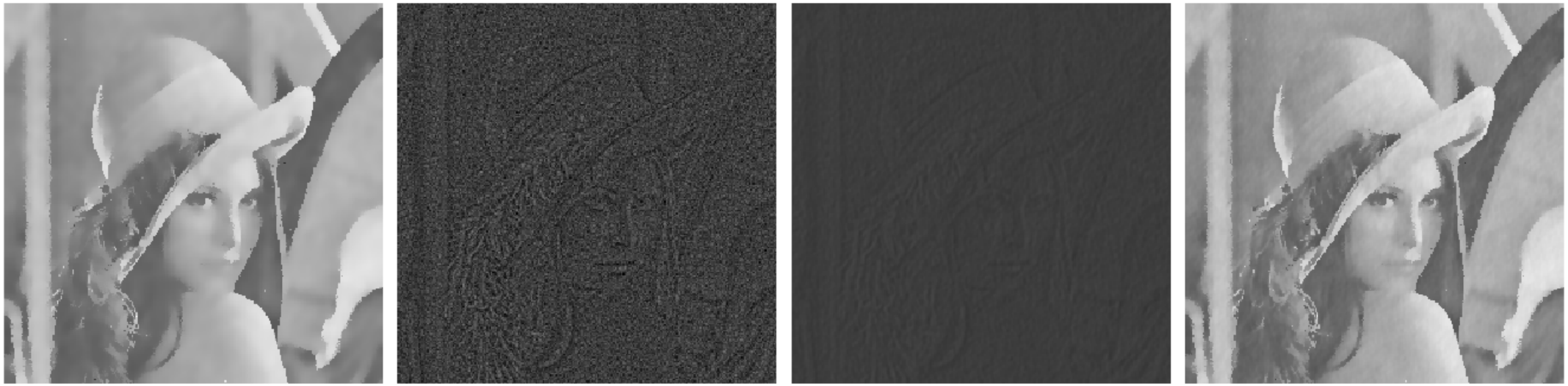
Iteration 2

Denoising Process Iterations



Iteration 3

Denoising Process Iterations



Iteration 4

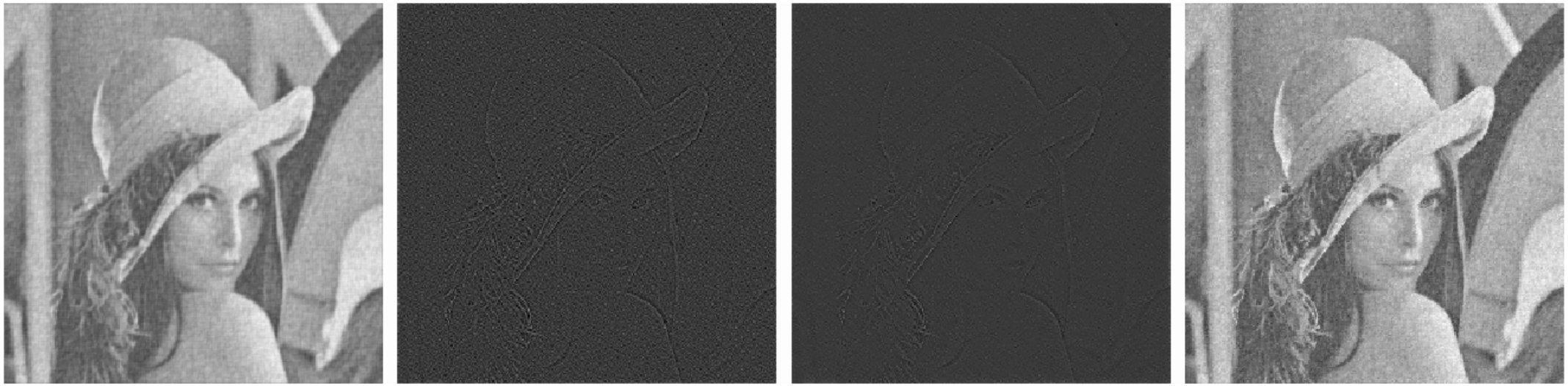
Denoising Algorithm Results

First iteration of denoising process (PSNR = 23.0), Final denoised result chosen (PSNR = 56.2) (L-R, Lena)

Denoising Algorithm Results

Original image, Noisy image (L-R, Lena)

Denoising Process Iterations

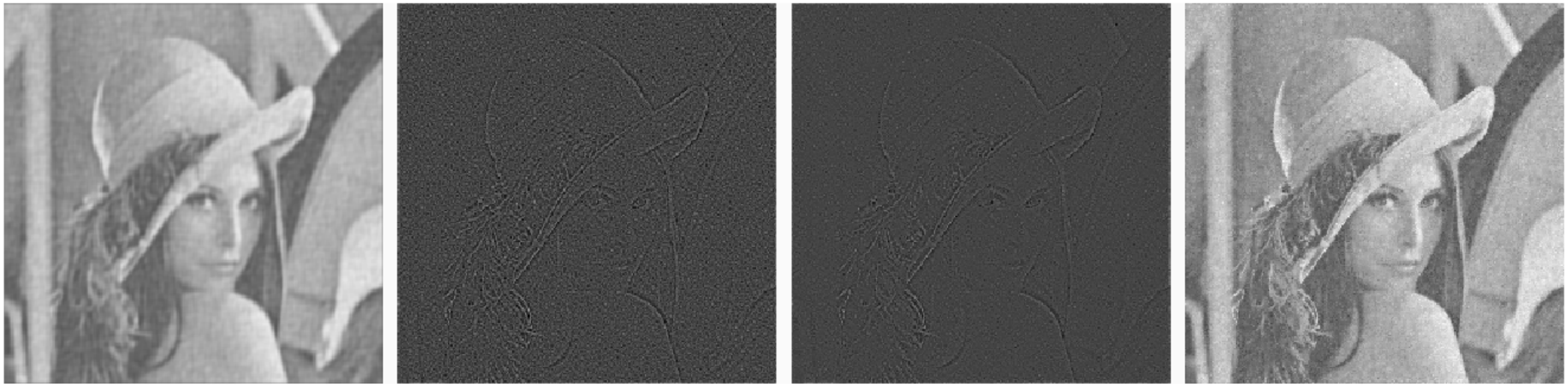


Iteration 1

L-R: Denoised Image for the iteration, Residual, Denoised Residual, Sum of denoised residual and denoised image

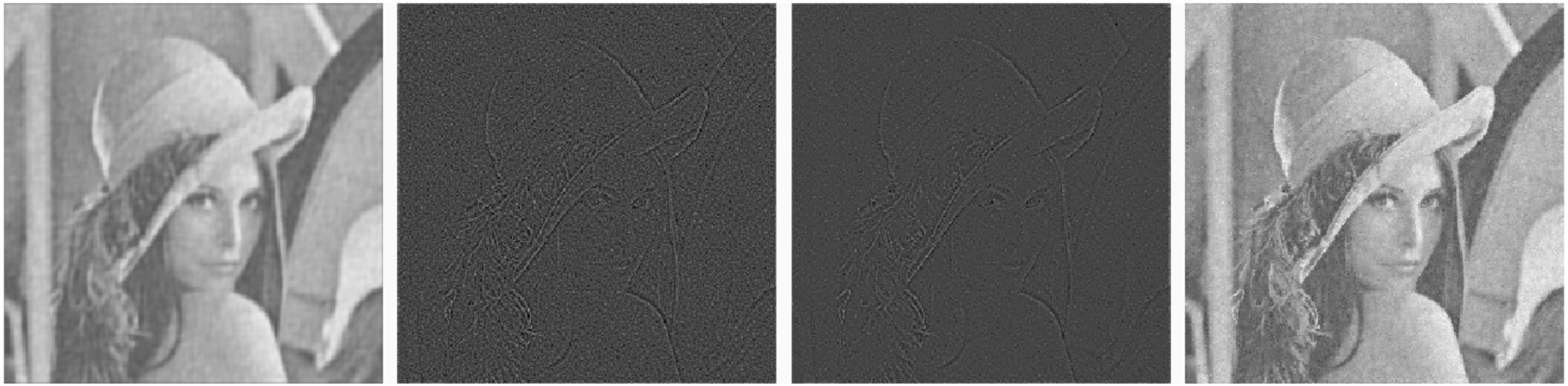
Image Denoising: Wiener Filter, Residual Denoising: Bilateral Filtering

Denoising Process Iterations



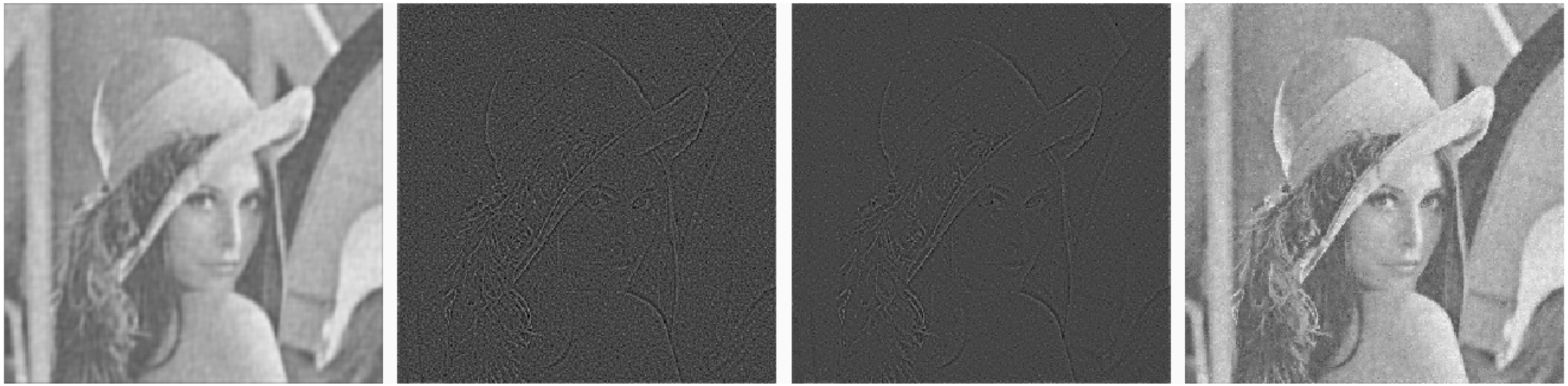
Iteration 2

Denoising Process Iterations



Iteration 3

Denoising Process Iterations



Iteration 4

Denoising Algorithm Results

First iteration of denoising process (PSNR = 26.7), Final denoised result chosen (PSNR = 33.3) (L-R, Lena)

Denoising Algorithm Results

Original image, Noisy image (L-R, Lena)

Denoising Algorithm Results

First iteration of denoising process (PSNR = 26.75), Final denoised result chosen (PSNR = 27.89) (L-R, Lena)

Drawbacks

- Excessive filtering is seen sometimes (for example in Lena), resulting in smoothing of fine texture. However noise is removed well.