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EXPERIMENT 7. IMAGE PROCESSING, 2D FFT, FILTERING, EDGE DETECTION
PART 2
LABORATORY REPORT

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Real-time Programming Tasks

- ***Add a scaling control for all the images in your block diagram for better visualization and preventing image clipping.***

a) Modify the contents of Edge Detection with 2D Convolution.vi such that you have a front panel similar to Figure 2 in manual. A part of the Block Diagram after modification looks like as shown in Figure 3 in manual.

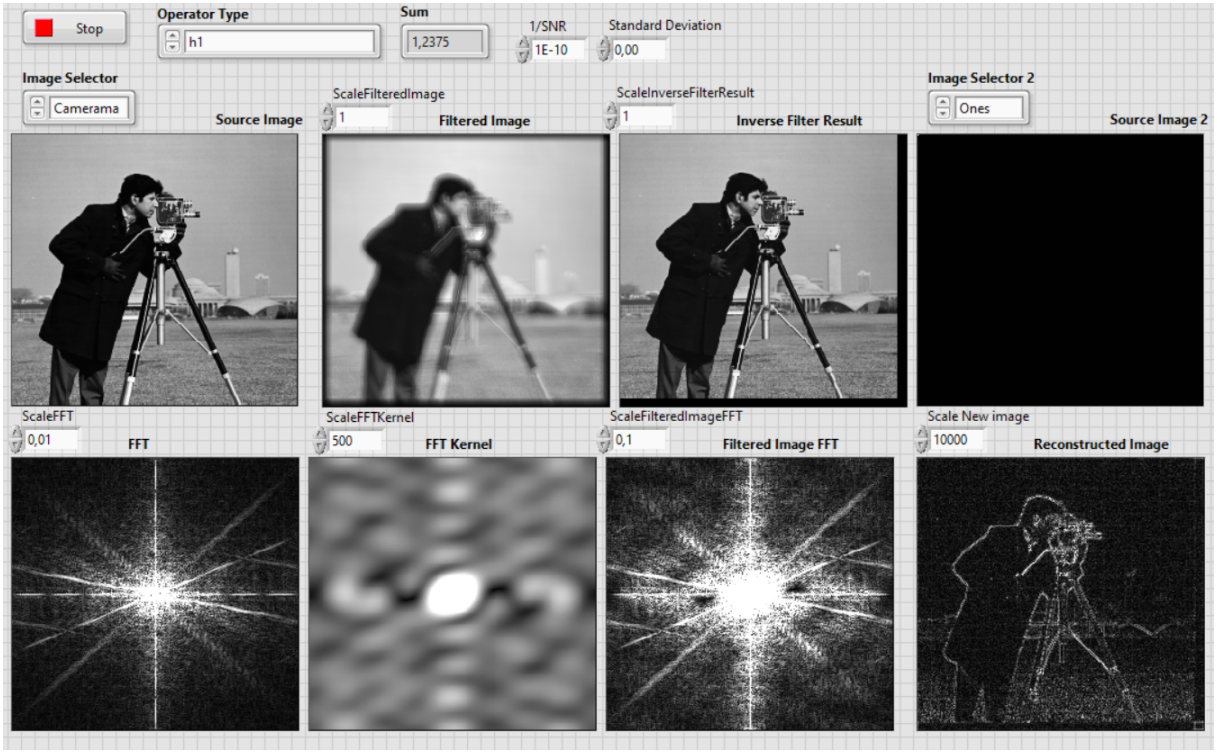

Figure 1: The front panel of modified Edge Detection with 2D Convolution

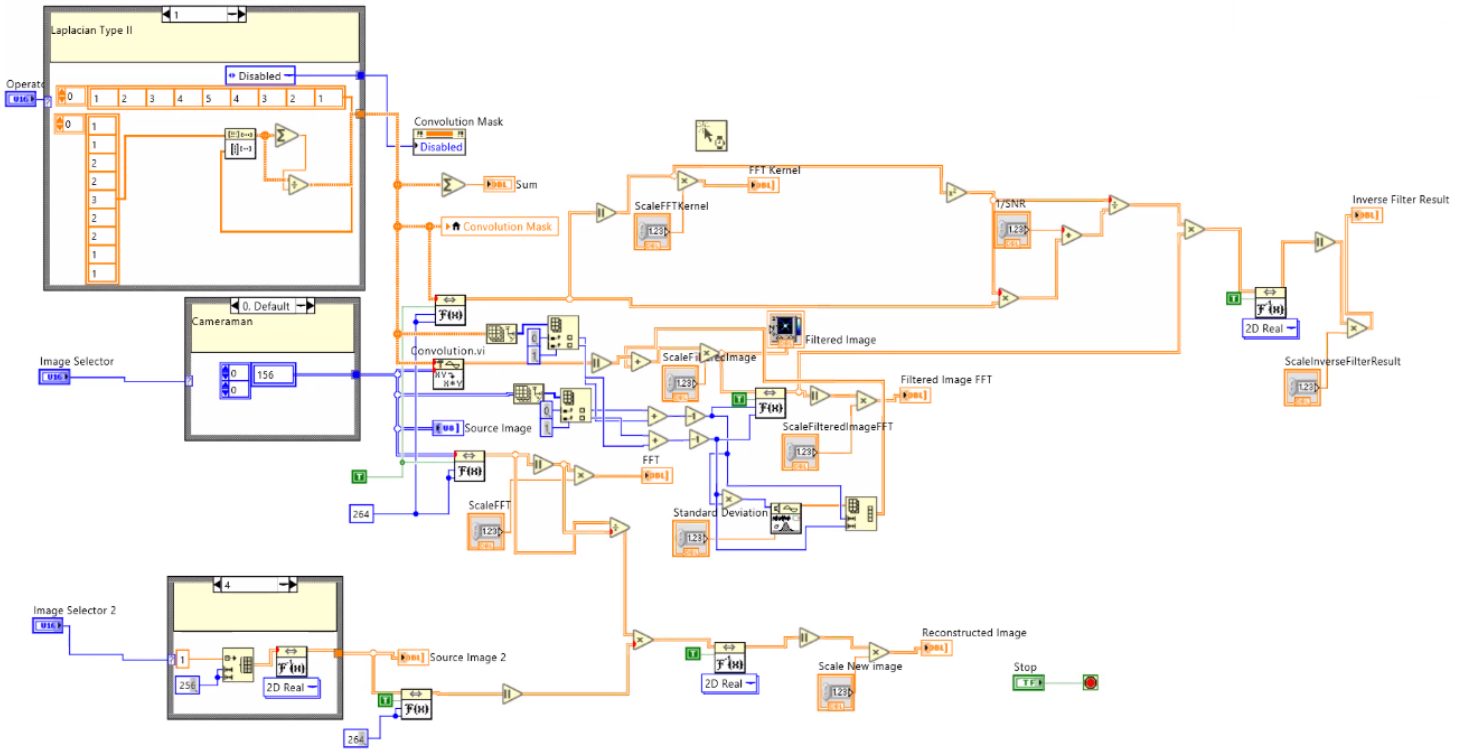

Figure 2: The block diagram of modified Edge Detection with 2D Convolution

b) Obtain the 2D Fourier transform of ***cameraman*** in order to visualize the low and high frequency components. You can try other image sources such as ***"Baboon"***, ***"Colombia"*** and ***"Couple"*** in order to see the differences between frequency contents. **Comment on** each image and its frequency characteristics. ***Don't forget to attach all the images and their FFT magnitude spectra.***

In Figures 3-6, we see scaled frequency components for each image. The frequency content of the image gives us information how the colors are distributed along the image. In all images we see that the DC component is very huge since it reflects the power of the image. Other components reflect the magnitude of complex exponentials constructing the image. Therefore, if the image changes more, in the FFT we see white color away from the center. Since "cameraman" image changes abruptly where man appears, its spectrum is wider and contains higher frequency. But in couple and baboon images, there are no abrupt changes, therefore the spectrum is narrower. In "columbia" image, the spectrum is wider because the image changes abruptly where the columns of the building and their shadows.

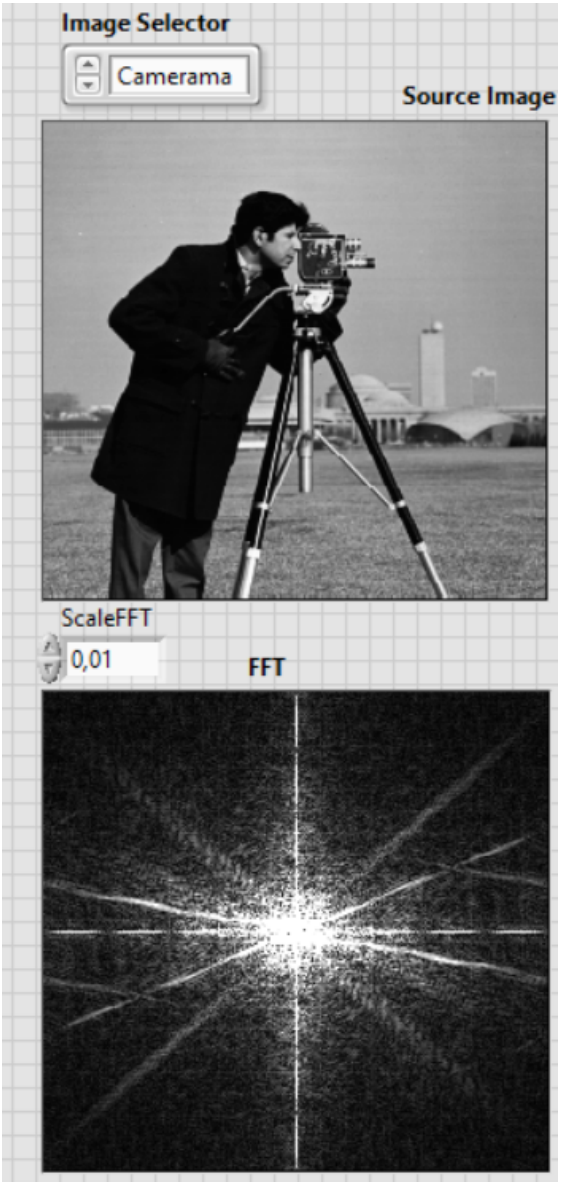

Figure 3: 2D Fourier transform of "cameraman"

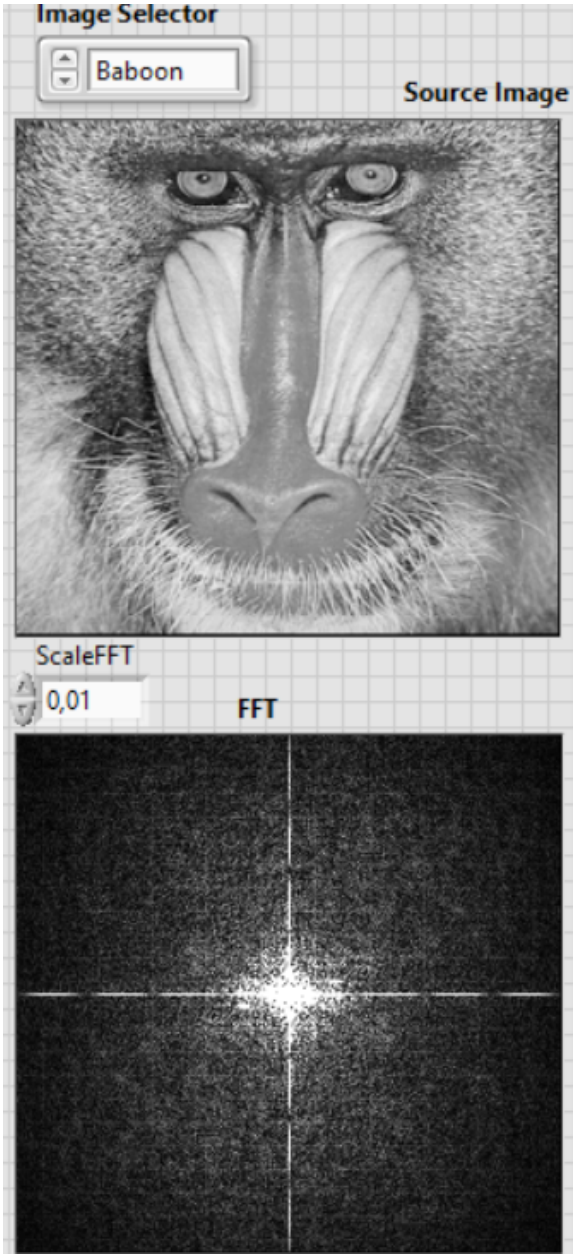

Figure 4: 2D Fourier transform of "baboon"

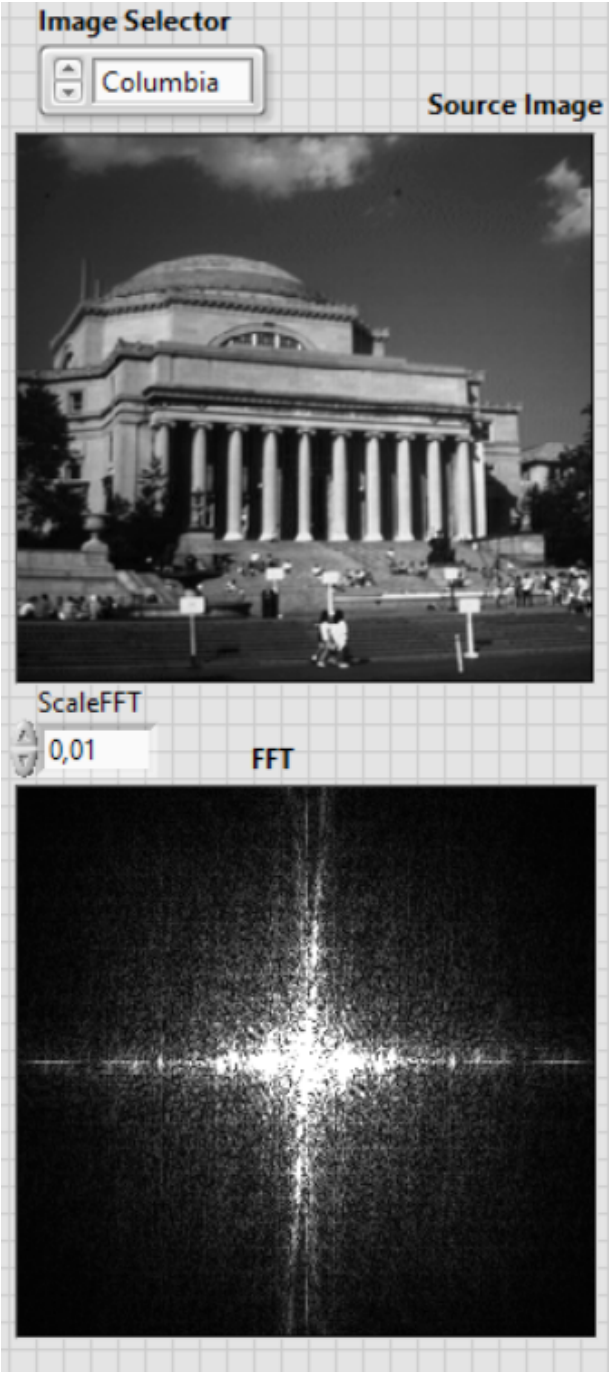

Figure 5: 2D Fourier transform of "colombia"

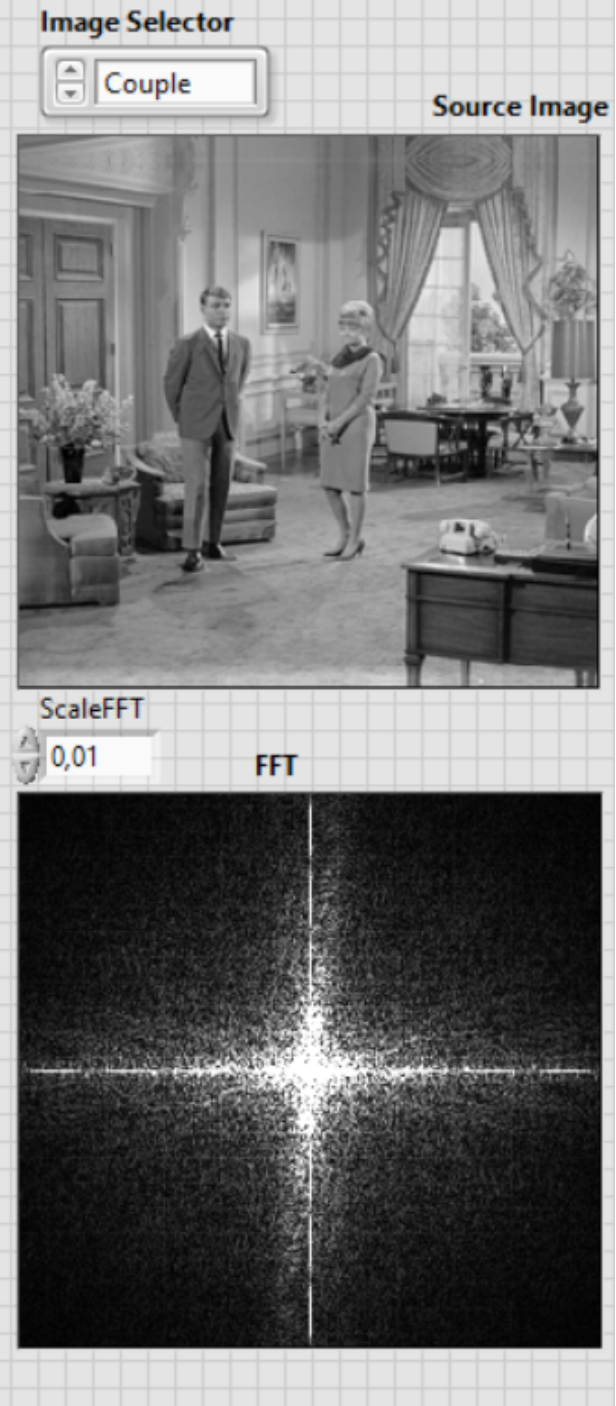

Figure 6: 2D Fourier transform of "couple"

c) Obtain the phase components of **cameraman**. Assume that the magnitude components are one and use 2D ifft to reconstruct the image by using only the phase information as shown in Fig. 5 (experiment 7 part 1 manual). **Try magnitudes of FFT of one of the other images** for the magnitude terms during the reconstruction. Can you obtain better reconstruction quality with this selection? **Comment** on your findings. ***Don't forget to attach the reconstructed images for both cases.***

When we look at Figures 7 and 8, we see that the shape of the image is decoded by phase characteristics. Magnitude response of the image helps to add color details of the image, i.e. power of the image on a certain frequency is given by the magnitude response. Since magnitude characteristics of "couple" is similar to magnitude characteristic of "cameraman", "couple" is used for reconstruction.

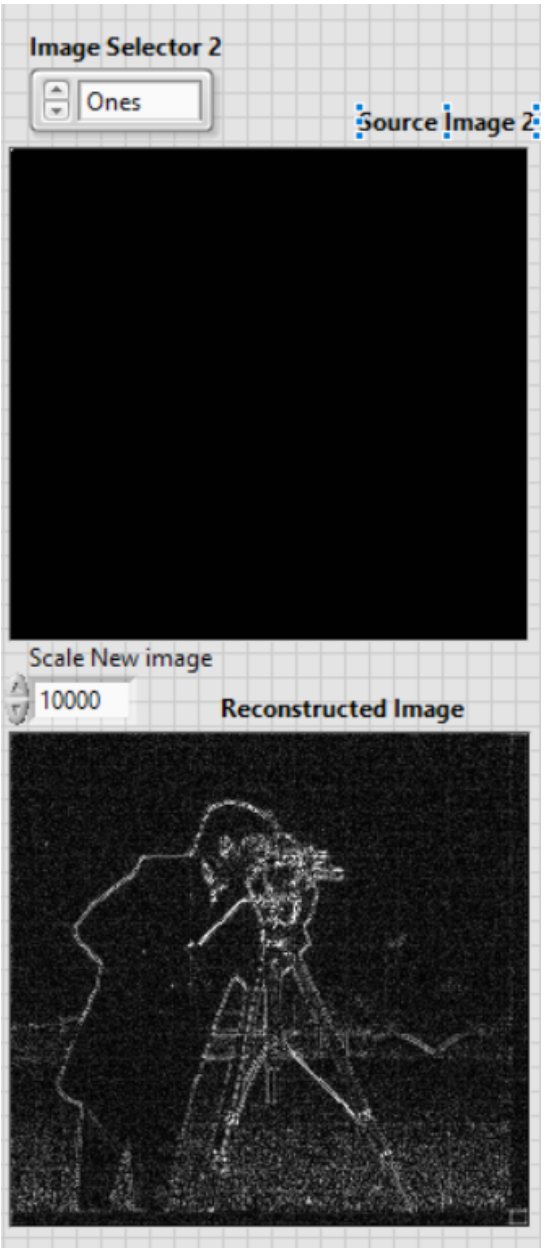

Figure 7: Reconstruction image from only phase components of "cameraman"

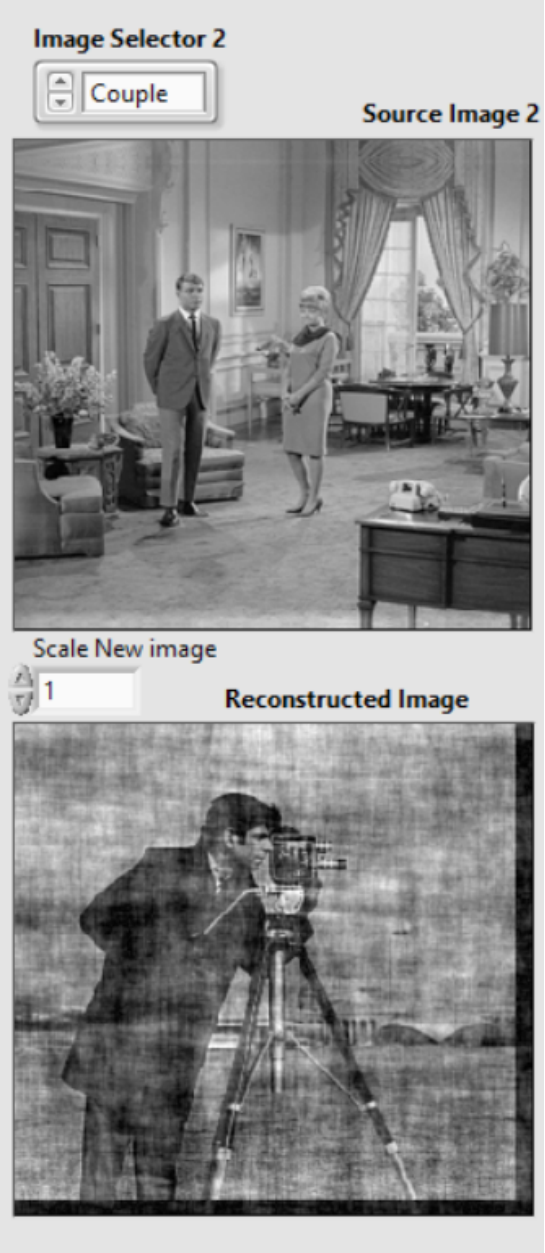

Figure 8: Reconstruction image from magnitude of "couple" and phase of "cameraman"

d) Increase the size of the Convolution Mask in Fig. 2 (experiment 7 part 2 manual) to 9x9. You can easily do that by enlarging the box with the mouse and entering numerical values. Repeat ***part e)*** in ***MATLAB*** Tasks. In this case you only need to implement the filtering using ***"convolution.vi"***. ***Don't forget to attach all the results.***

When we compare Figure 9 with 10 and Figure 11 with 12, we see that the image filtered with linear phase filter is more clear whereas the image with nonlinear phase filter is distorted and is more blurry. This is due to phase characteristics of the filters, when we look at the nonlinear phase filter we see that the phase information will be lost in the resulting image because linearity in phase results in a shift in spatial dimension, however, the filter does not provide equal shifts for each frequency rather it shifts each frequency differently. Therefore, we observe distorted and blurry images if we filter with nonlinear phase filters. Also, from Part c, we know that image shape is determined by phase characteristics, therefore we expect that shapes are distorted in nonlinear phase filters.

h1=

0.0217 0.0082 0.0177 0.0226 0.0052 0.0092 0.0165 0.0071 0.0191
0.0193 0.0094 0.0089 0.0080 0.0235 0.0115 0.0085 0.0007 0.0007
0.0038 0.0155 0.0141 0.0167 0.0134 0.0207 0.0188 0.0019 0.0049
0.0193 0.0087 0.0035 0.0219 0.0191 0.0212 0.0231 0.0040 0.0214
0.0193 0.0021 0.0009 0.0097 0.0122 0.0217 0.0160 0.0080 0.0193
0.0115 0.0087 0.0132 0.0127 0.0198 0.0014 0.0146 0.0231 0.0118
0.0193 0.0021 0.0066 0.0207 0.0021 0.0085 0.0172 0.0195 0.0094
0.0005 0.0137 0.0005 0.0094 0.0113 0.0089 0.0127 0.0186 0.0045
0.0188 0.0181 0.0014 0.0127 0.0137 0.0118 0.0082 0.0141 0.0198

h2=

0.0027 0.0027 0.0053 0.0053 0.0080 0.0053 0.0053 0.0027 0.0027
0.0053 0.0053 0.0107 0.0107 0.0160 0.0107 0.0107 0.0053 0.0053
0.0080 0.0080 0.0160 0.0160 0.0240 0.0160 0.0160 0.0080 0.0080
0.0107 0.0107 0.0213 0.0213 0.0320 0.0213 0.0213 0.0107 0.0107
0.0133 0.0133 0.0267 0.0267 0.0400 0.0267 0.0267 0.0133 0.0133
0.0107 0.0107 0.0213 0.0213 0.0320 0.0213 0.0213 0.0107 0.0107
0.0080 0.0080 0.0160 0.0160 0.0240 0.0160 0.0160 0.0080 0.0080
0.0053 0.0053 0.0107 0.0107 0.0160 0.0107 0.0107 0.0053 0.0053
0.0027 0.0027 0.0053 0.0053 0.0080 0.0053 0.0053 0.0027 0.0027

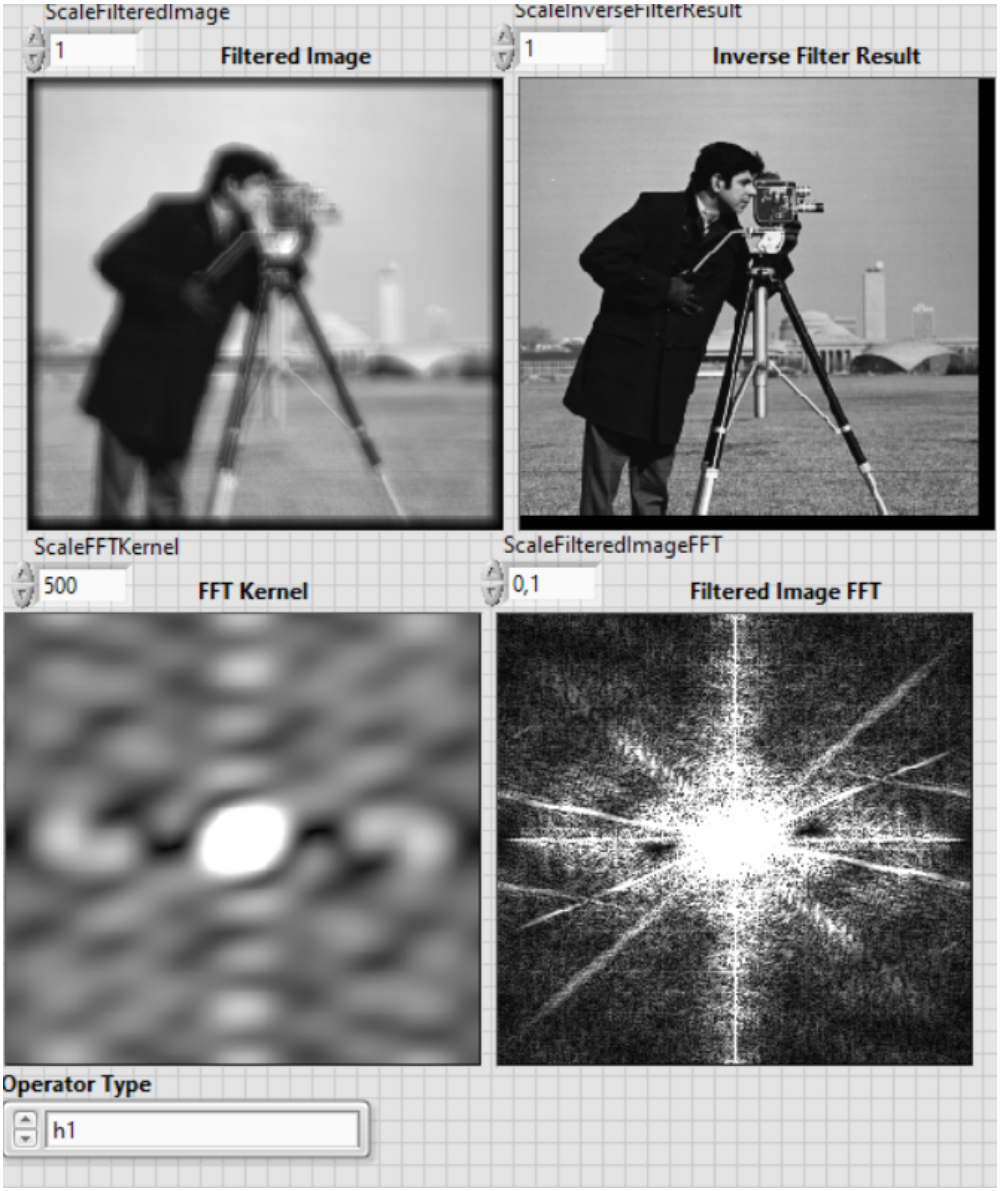

Figure 9: Filtered "cameraman" by the filter "h1"

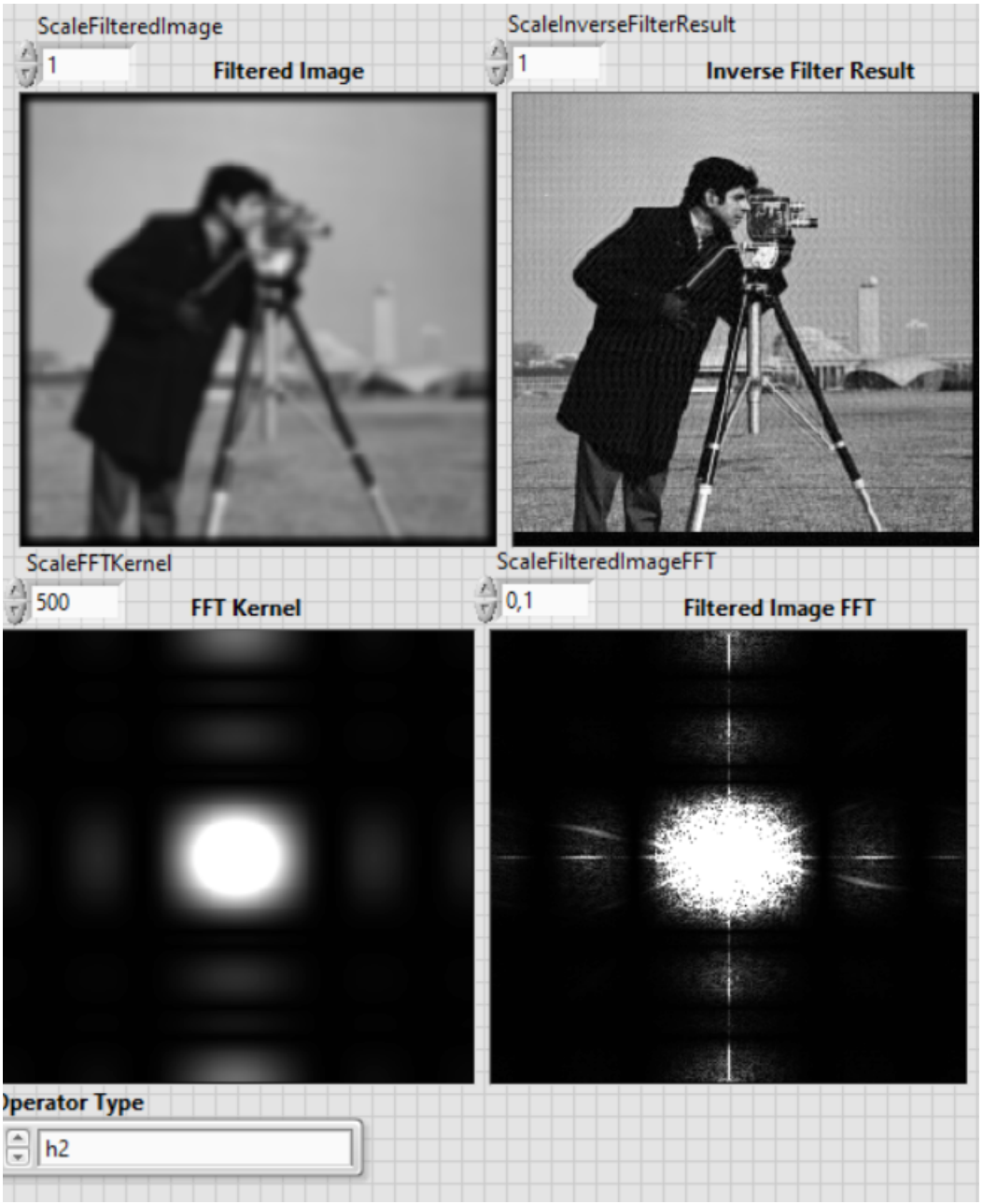

Figure 10: Filtered "cameraman" by the filter "h2"

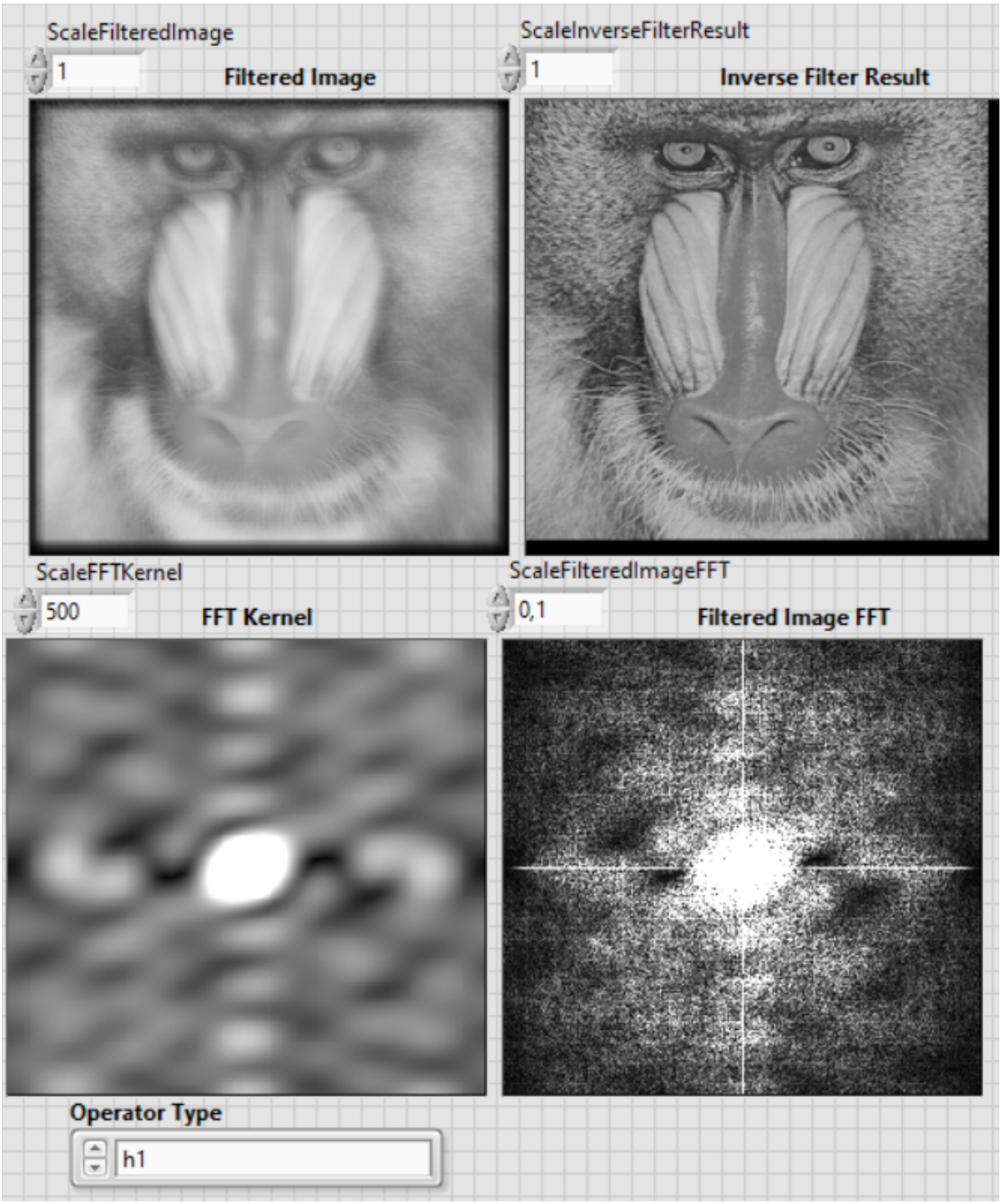

Figure 11: Filtered "baboon" by the filter "h1"

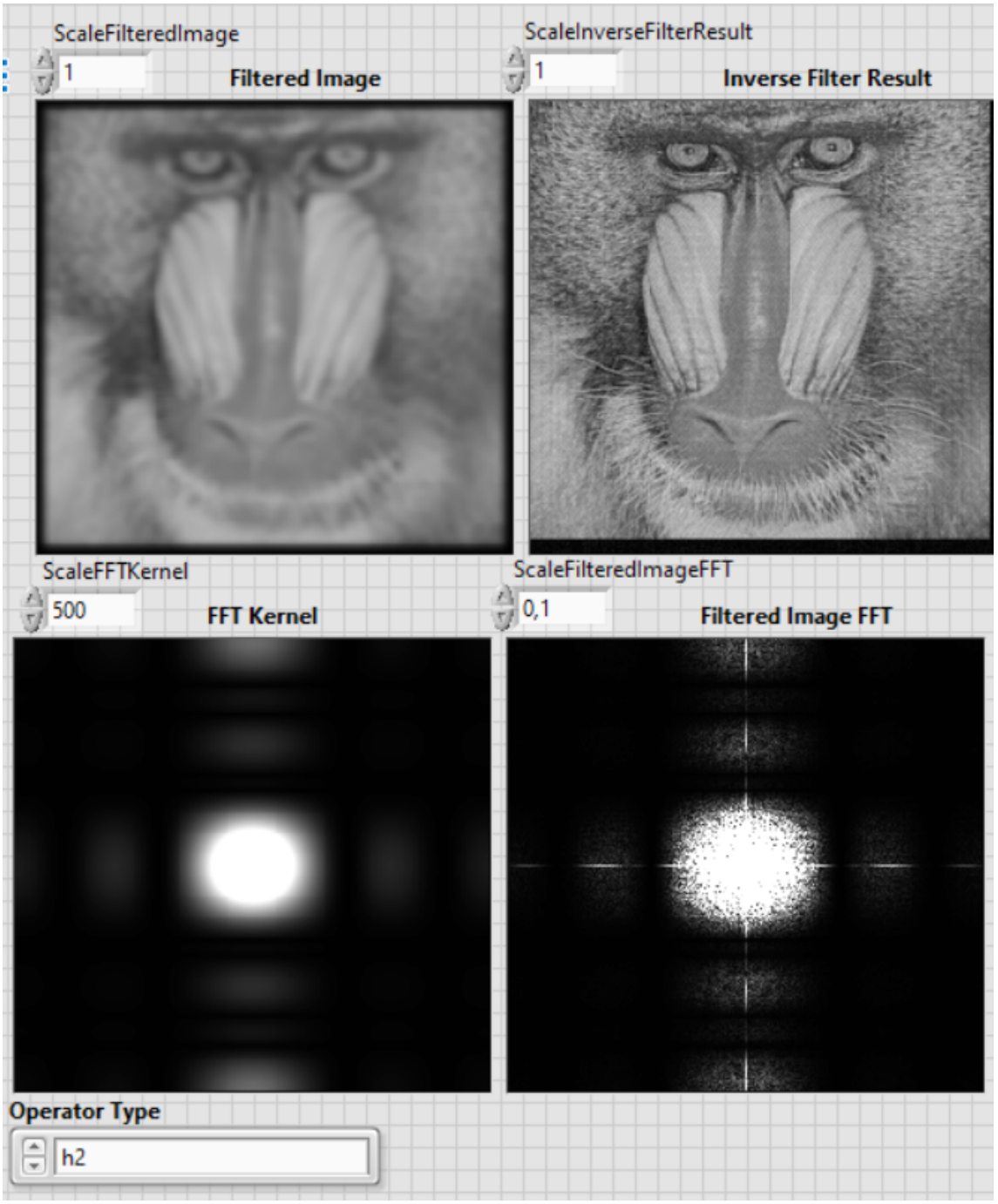

Figure 12: Filtered "baboon" by the filter "h2"

e) Repeat ***part f)*** in ***MATLAB*** Tasks. In this case, you can use the available image sources instead of ***Lena***. Try all the images and comment on their reconstruction quality. **Try at least 2 different noise levels, one for low and the other for relatively high noise. You don't need to compute LSE in this part.** ***Don't forget to attach all the results.***

Reconstruction quality gets worse when a higher noise level is present in the image, this is due to the inverse filter. When there is noise and filter response is small, there is noise amplification. Thus, it is possible to obtain an optimum solution in the MSE sense to decrease the noise amplification. This inverse filter is called the inverse Wiener filter. As can be seen from Figure 13, when there is a low noise level, the inverse filter cancels the noise and a better quality image is obtained. Although the image is not at a good quality, even when a high noise level is present, the inverse filtered image is better than the filtered image as seen from Figure 14. This effect can also be seen for other images in Figures 15-20.

Figure 13: Filtered noisy "cameraman" and reconstruction with the filter "h2", where std=1

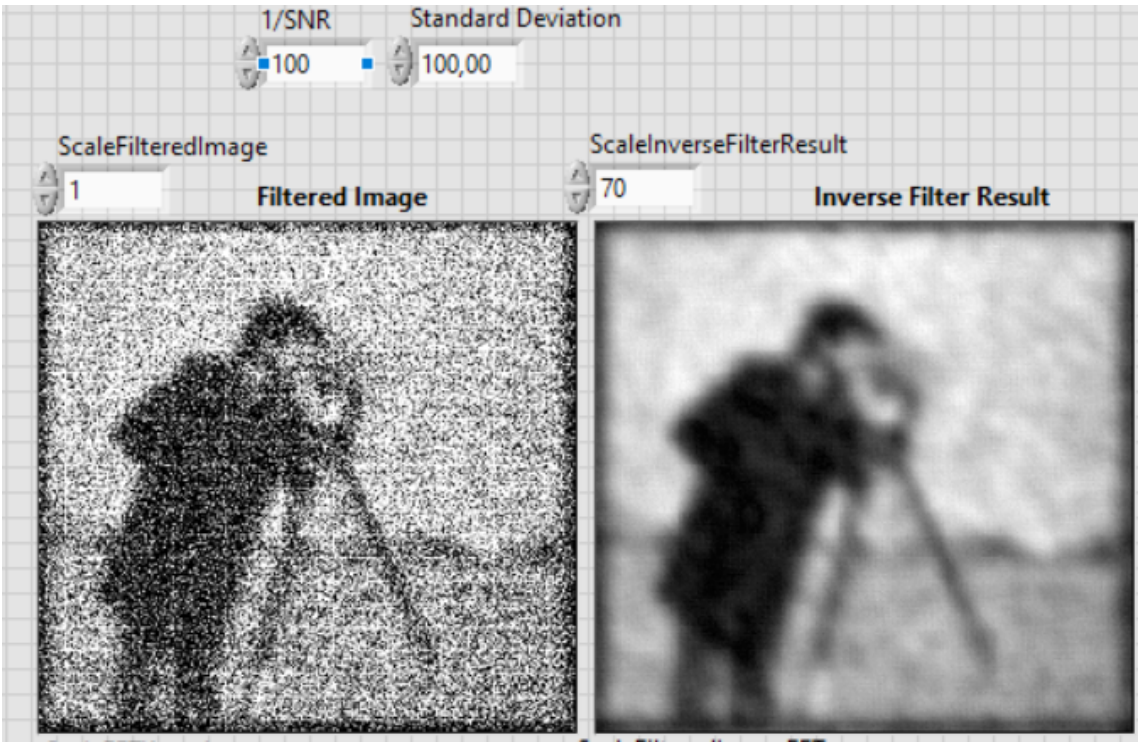

Figure 14: Filtered noisy "cameraman" and reconstruction with the filter "h2", where std=100

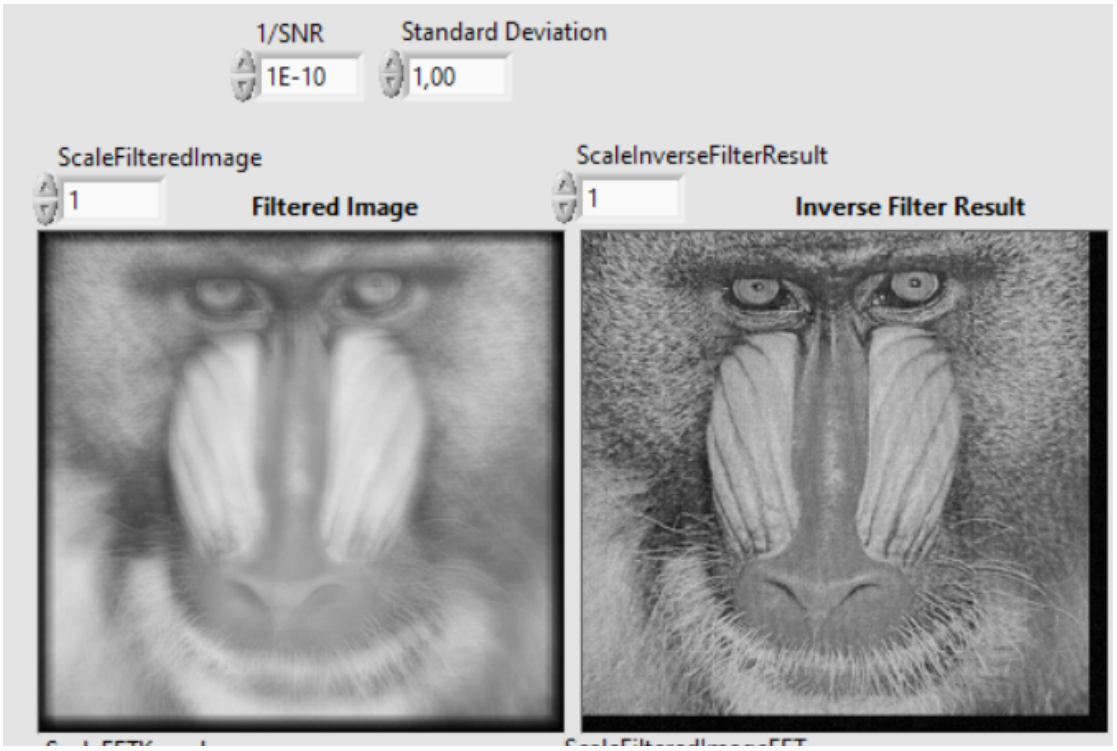

Figure 15: Filtered noisy "baboon" and reconstruction with the filter "h2", where std=1

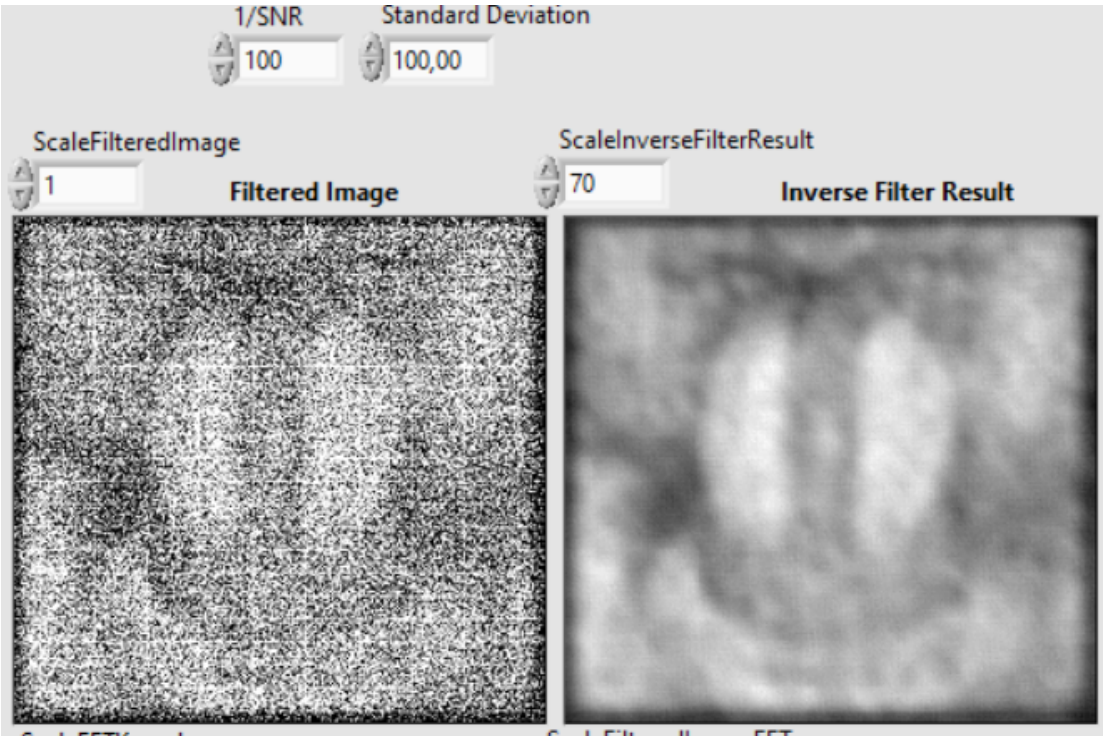

Figure 16: Filtered noisy "baboon" and reconstruction with the filter "h2", where std=100

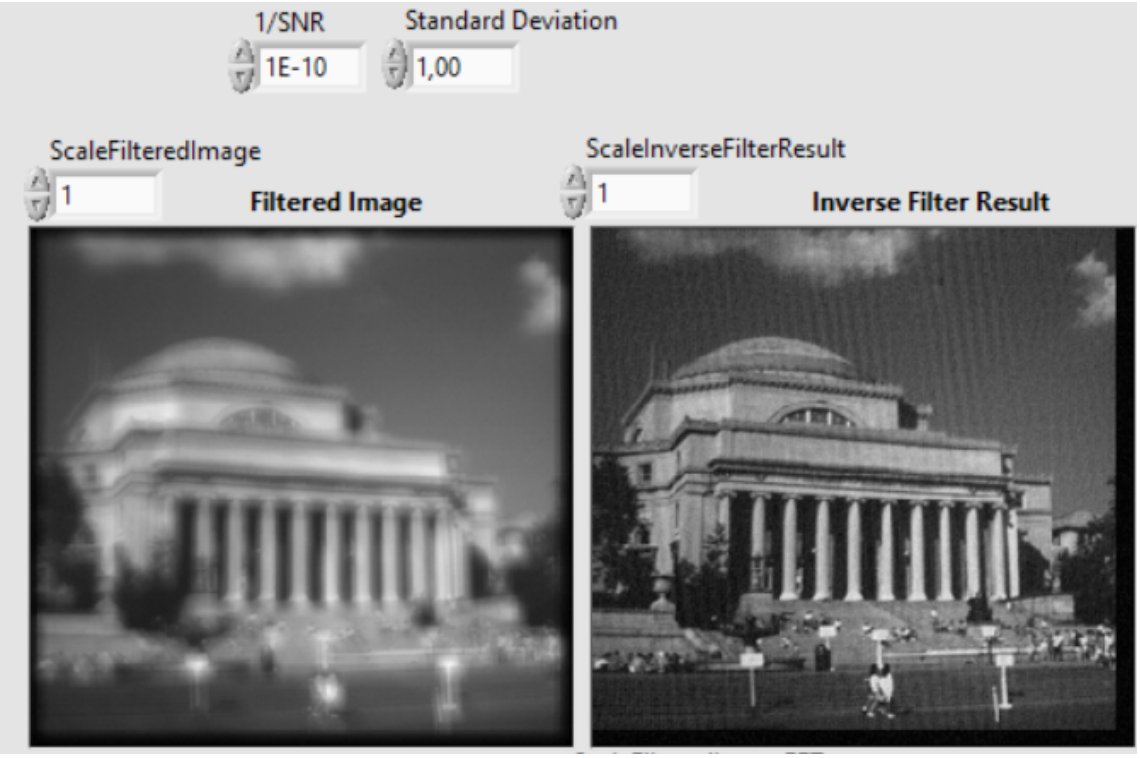

Figure 17: Filtered noisy "colombia" and reconstruction with the filter "h2", where std=1

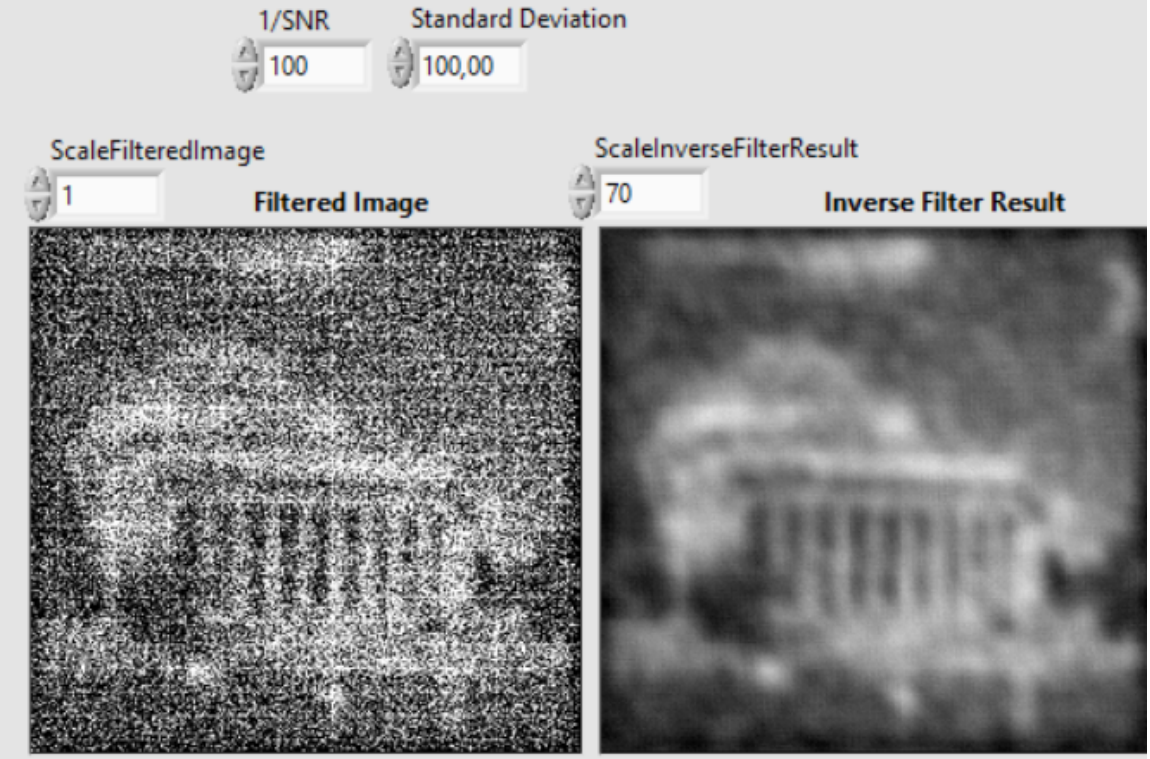

Figure 18: Filtered noisy "colombia" and reconstruction with the filter "h2", where std=100

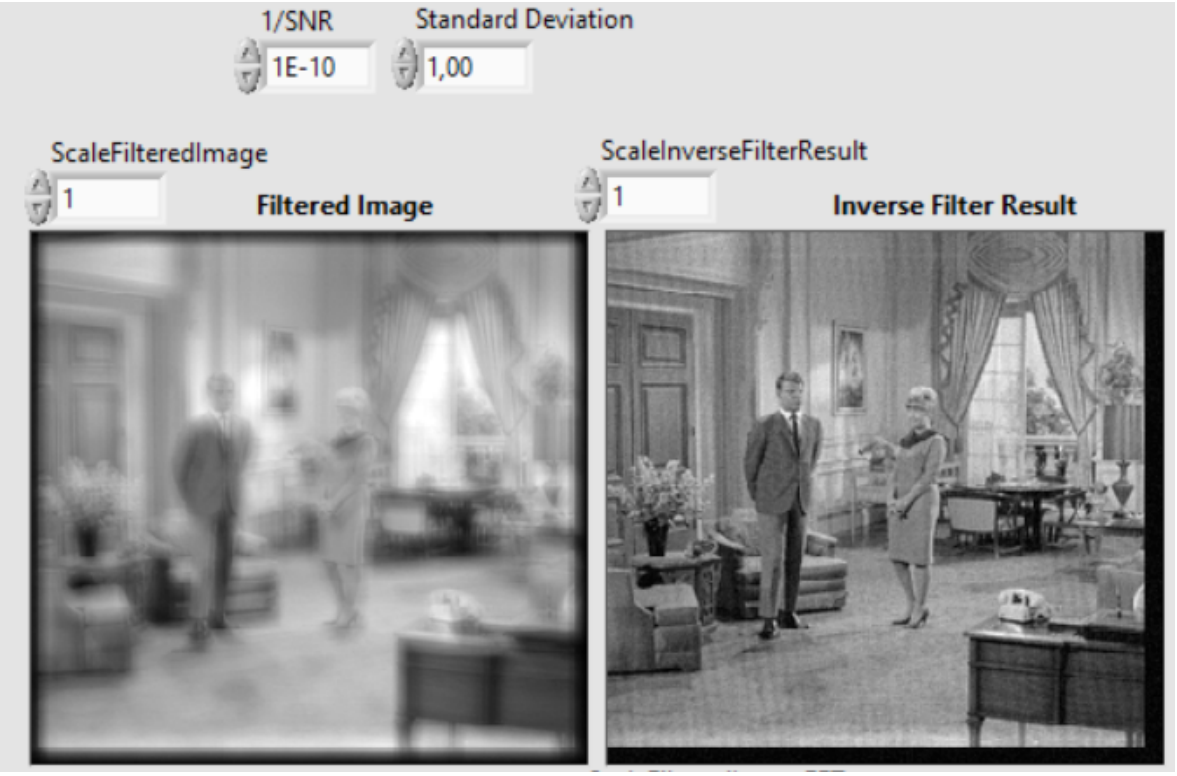

Figure 19: Filtered noisy "couple" and reconstruction with the filter "h2", where std=1

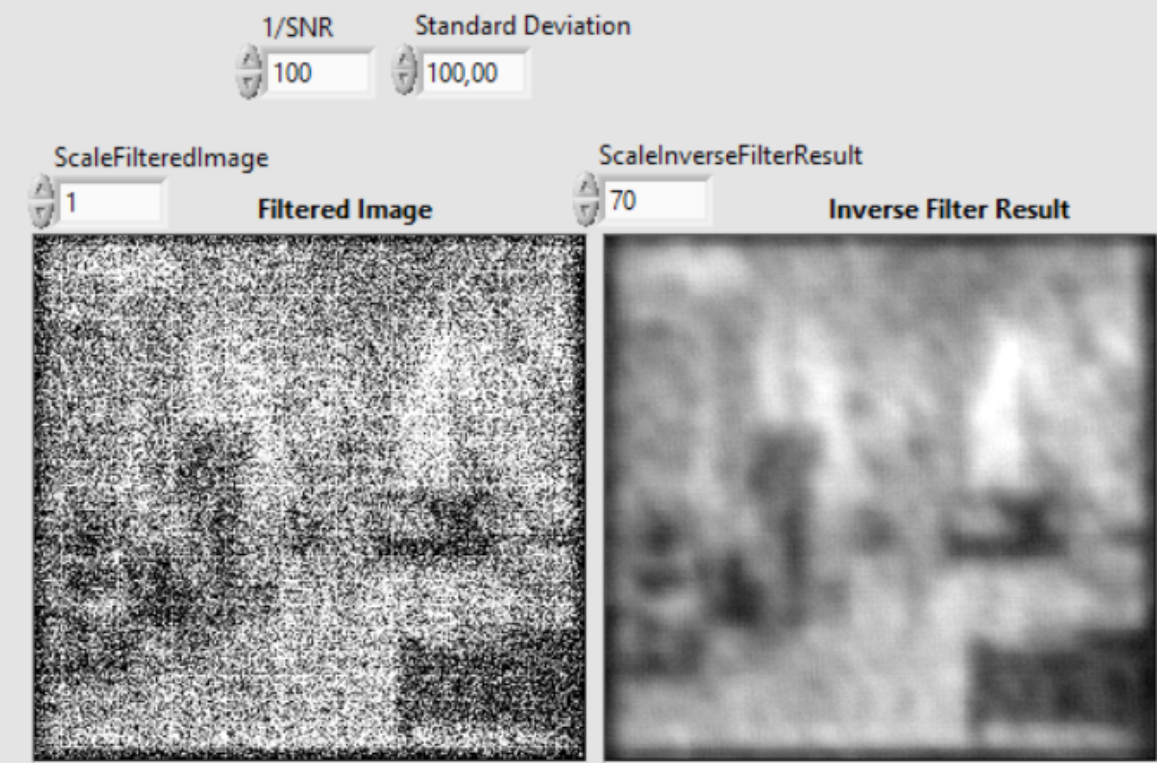

Figure 20: Filtered noisy "couple" and reconstruction with the filter "h2", where std=100