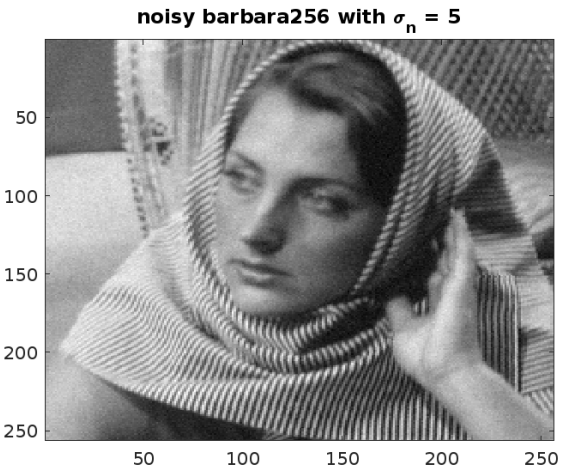
Question 8:

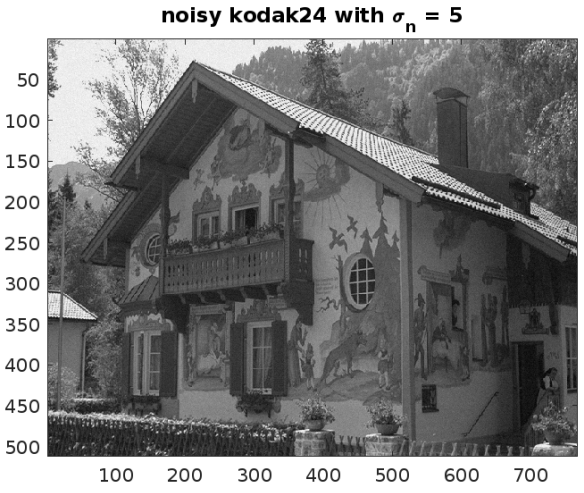
Consider the two images in the homework folder ‘barbara256.png’ and ‘kodak24.png’. Add zero mean Gaussian noise with standard deviation σ = 5 to both of them. Implement a bilateral filter and show the outputs of the bilateral filter on both images for the following parameter configurations: (σs = 2, σr = 2); (σs = 0.1, σr = 0.1); (σs = 3, σr = 15). Comment on your results in your report. Repeat when the image is corrupted with zero-mean Gaussian noise of σ = 10 (with the same bilateral filter parameters). Comment on your results in your report. For the bilateral filter implementation, write a MATLAB function mybilateralfilter.m which takes as input an image and parameters σr, σs. Implement your filter using at the most two nested for-loops for traversing the image indices. For creating the filter, use functions like meshgrid and vectorization for more efficient implementation. Include all image outputs as well as noisy images in the report. [15 points]

Solution :

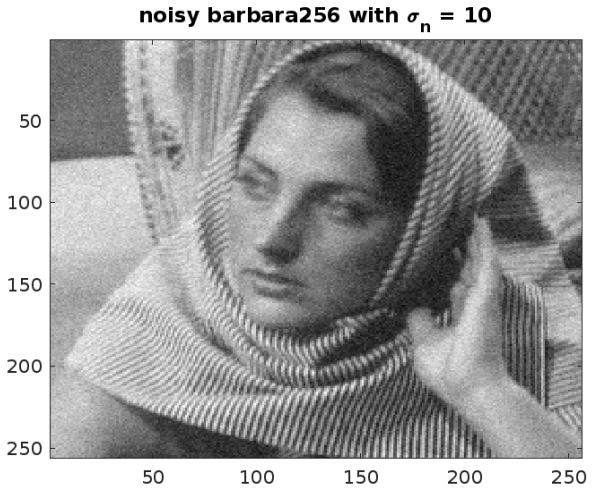
Original Images

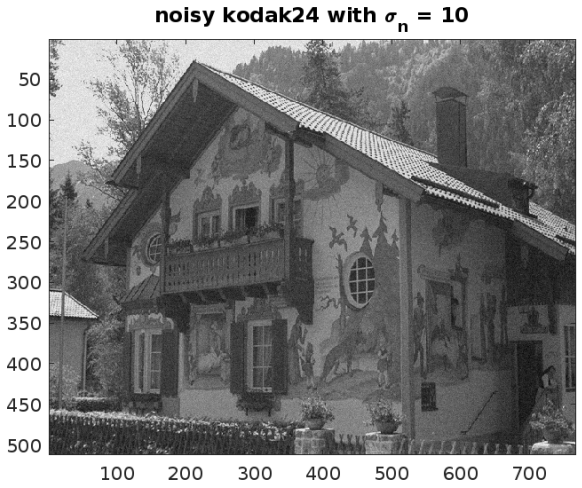
Images after adding Gaussian Noise with standard deviation of 5





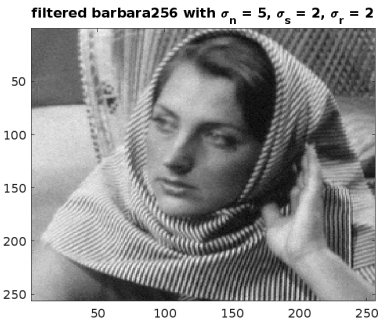
Images after adding Gaussian Noise with standard deviation of 10

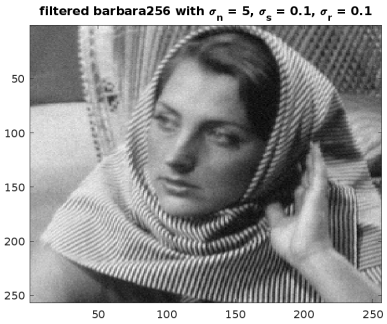


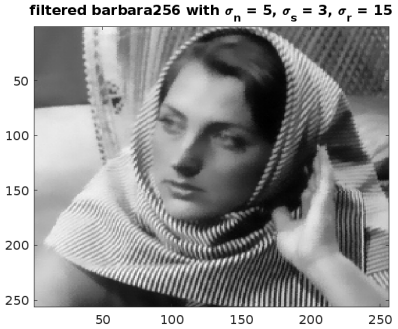


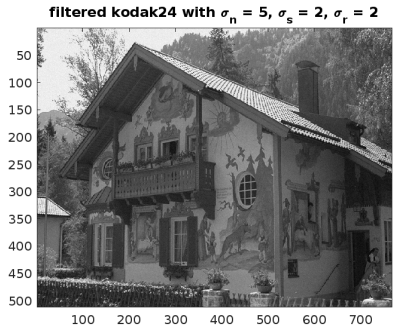
Images with Gaussian noise of standard deviation higher are more blurrier and having more noise than the images with less standard deviation

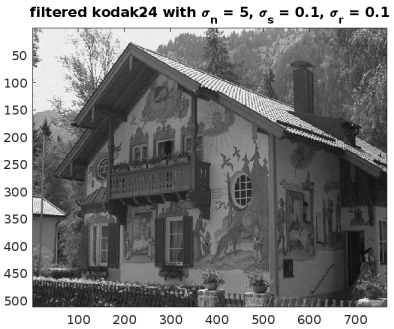
Images with varying σ_s *and* σ_r

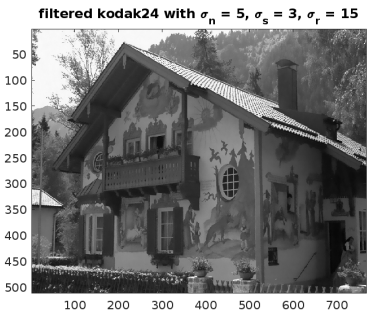






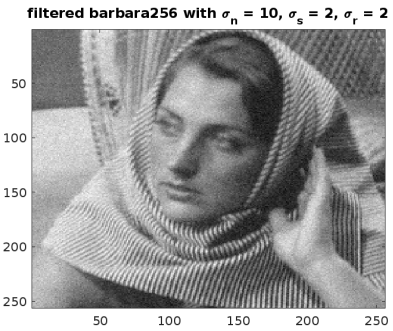


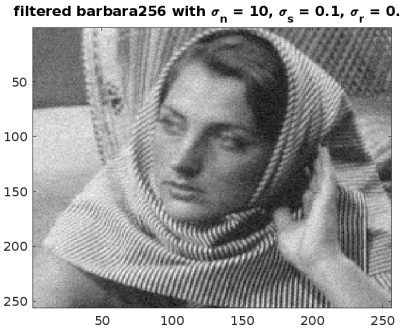


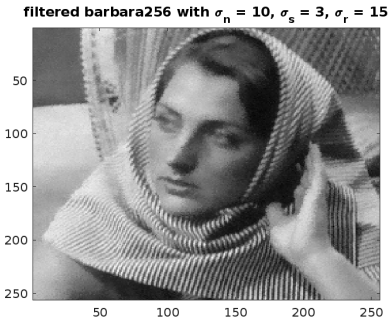


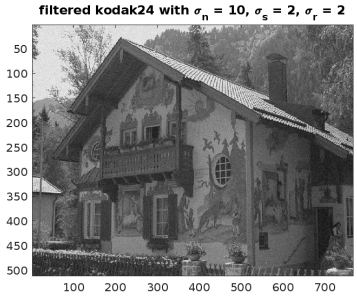
From the above figures, we see that as we go for higher values of σ_s and σ_r, the image gets more blurred and some smoothing of images could be seen. This is because more neighboring pixels have significant weights in the gaussian filters. The gaussian distribution widens as the standard deviation increases. We also note that the blurring is more when σ_r is large, σ_r controls the extent of different intensity pixels adding up in the mean. Though bilateral filtering blurs the image, the edges are still preserved. The same can be observed for the following kodak images. Higher

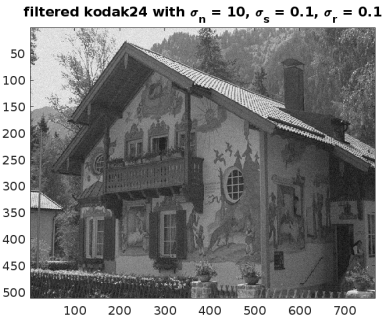
values of σ_s and σ_r can provide stronger smoothing and noise reduction but may also lead to a loss of fine details and sharp edges in the image for higher values.

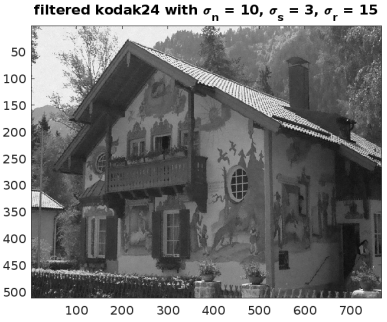












As we increase the standard deviation of gaussian noise, the intensities have more error now. Hence we expect to see better filtering results than the previous one, but low σ_s and σ_r doesn't provide much smoothing to the noisy images. Hence we only observe smoothing for $\sigma_s = 3$ and $\sigma_r = 15$ as we could see in the following images.