OBSERVATIONS

- **Input:**
  - The image files provided (converted into Grayscale).
  - Gaussian and Salt & pepper noise is added to these images explicitly, based on the parameters specified in the code. These parameters are the sigma (sq. root of variance) value for the Gaussian, and prob (a minimum threshold fixed, below which the pixel is marked 0, and above 1-prob, the pixel is marked 255).
  - The PSNR and MSE values of the noisy image are calculated, just after these images are produced, so as to compare the performance of the denoising methods.

- **Output:**
  - The output is the denoised image, and the PSNR and MSE metrics computed on them, for the comparison of performance.

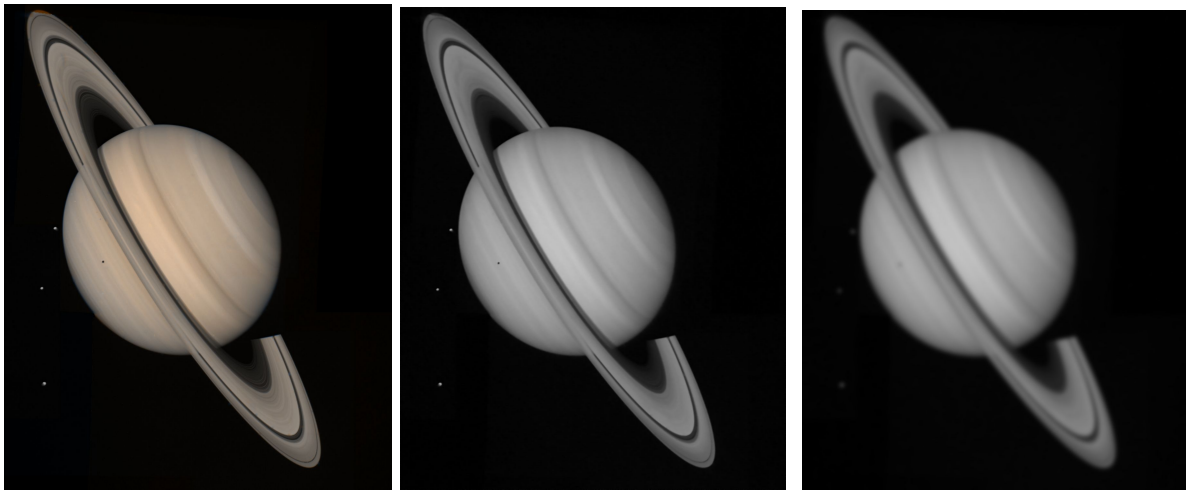
- **Results:**
  1. Gaussian Noise:

  a. Best result with Non Local Means Filter:

Original Image | With NLM Filter | With Gaussian Filter

PSNR of Noisy Image	33.35391618279945
MSE of Noisy Image	30.039226295885634
PSNR of denoised image (with NLM Filter)	36.53794762570055
MSE of denoised image (with NLM Filter)	14.430640192168726
PSNR of denoised image (with Gaussian Filter)	33.69802843817979
MSE of denoised image (with Gaussian Filter)	27.75092840899039

b. Best Results with Gaussian Filter:



Original Image With NLM Filter With Gaussian Filter

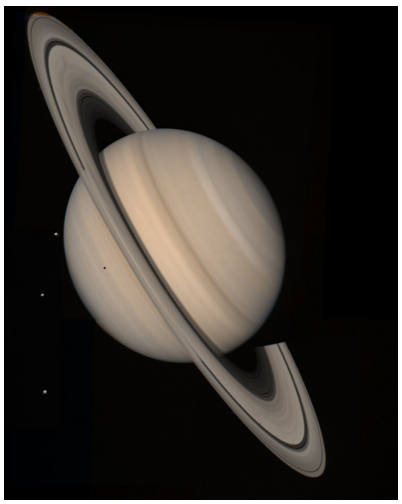
PSNR of Noisy Image	33.35970067479729
MSE of Noisy Image	29.99924282760133
PSNR of denoised image (with NLM Filter)	43.08598045828744
MSE of denoised image (with NLM Filter)	3.195084254726823
PSNR of denoised image (with Gaussian Filter)	32.91868351910472
MSE of denoised image (with Gaussian Filter)	33.20565175799635

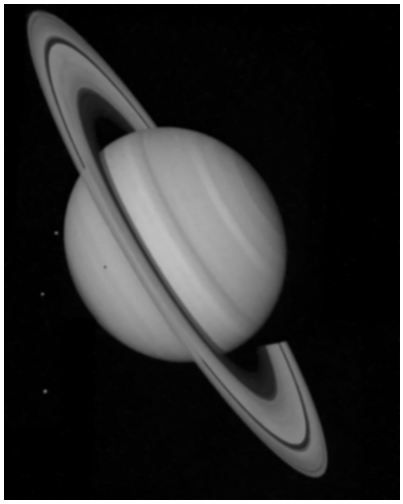
Note: In general, the Gaussian filter when used one the noisy image, blurs it. This turns out in a poor visual quality of the image (and affects the image quality metrics like PSNR and MSE). However, the NLM filter preserves the edges, it is more complex (in terms of parameter tuning and the time of computation) while the Gaussian filtering method being much more simpler, gave excellent results on the image shown. The reason being that the image resolution was very high. Thus, the blurred edges are not visible to the eyes. While, in general, to prevent the

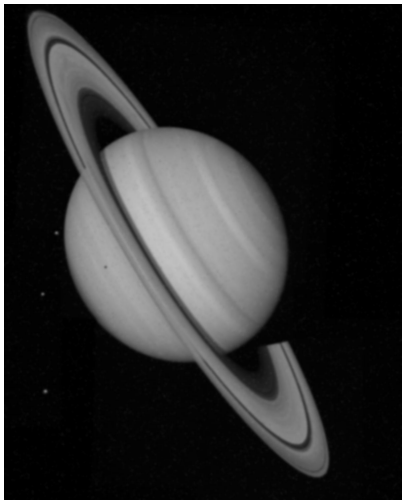
edges in the image from getting blurred, the Non local means filter proves to be better for the Gaussian noise.

2. Salt and Pepper Noise:

   a. Best Results with Non Local Means Filter and Gaussian Filter:


Original Image


With NLM Filter


With Gaussian Filter

PSNR of Noisy Image	53.0029742074348
MSE of Noisy Image	0.3256738888888889
PSNR of denoised image (with NLM Filter)	42.24594205977725
MSE of denoised image (with NLM Filter)	3.8769138888888888
PSNR of denoised image (with Gaussian Filter)	39.51776499896702
MSE of denoised image (with Gaussian Filter)	7.266141666666667

Note: The best results were generated on the same image by both Non local means and the Gaussian filtering methods (the region being the high resolution of the image). However, in general, the salt and pepper noise is different in nature as the pixel values are deviating from the original value at specific points (which are random). Thus, any blurring filter which averages out the pixel values from its immediate neighbours works fine for such a noise, in terms of visual quality, while it was noted that the overall PSNR and MSE values for the image were affected (negatively) and the edges were blurred by the Gaussian filter.
On the other hand, with the non local means filter, keeping a relatively smaller window size, as compared to the Gaussian noise filtering case, the results generated were better than the Gaussian filters.