Assignment 3: CS 663, Fall 2021

Question 1

- Consider the two images in the homework folder 'barbara256.png' and 'kodak24.png'. Add zero-mean Gaussian noise with standard deviation $\sigma = 5$ to both of them. Implement a mean shift based filter and show the outputs of the mean shift filter on both images for the following parameter configurations: $(\sigma_s = 2, \sigma_r = 2); (\sigma_s = 0.1, \sigma_r = 0.1); (\sigma_s = 3, \sigma_r = 15)$. Comment on your results in your report. Repeat when the image is corrupted with zero-mean Gaussian noise of $\sigma = 10$ (with the same bilaterial filter parameters). Comment on your results in your report. Include all image ouputs as well as noisy images in the report. [20 points]

Answer:

$$\boldsymbol{\sigma = 5}$$

Barbara256:

Barbara original image

Barbara noisy image for $\sigma = 5$

The above noisy image is a result of adding gaussian noise of mean 0 and standard deviation 5.

Mean shift Filtering:

Filtered barbara image with $\sigma_s = 0.1,\ \sigma_r = 0.1$

Filtered barbara image with $\sigma_s = 2,\ \sigma_r = 2$

Filtered barbara image with $\sigma_s = 3,\ \sigma_r = 15$

We have used $\epsilon = 0.01$ as the max value a feature vector can change by to stop the convergence process. By comparison we observed that the filtered image has not changed for $\sigma_s = 0.1,\ \sigma_r = 0.1$, few small regions have been smoothed for $\sigma_s = 2,\ \sigma_r = 2$ and an extensive filtering for the third case.

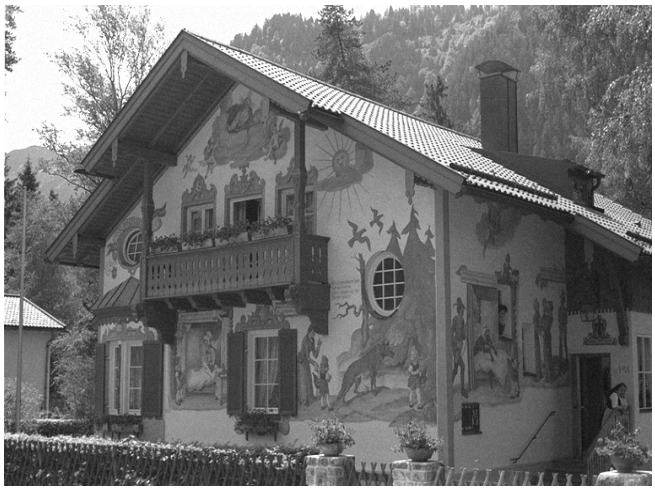
This is because, as we go for higher values of $\sigma_s,\ \sigma_r$ the number of local maximas of the kernal density estimate decrease which makes more pixels to converge to the same point. For $\sigma_s = 0.1,\ \sigma_r = 0.1$, every feature vector is a local maxima and hence every pixel is a cluster point of itself.

We have also observed that the convergence takes more time for higher $\sigma_s,\ \sigma_r$ values because with fewer local maximas, a pixel is at more distant to reach through gradient ascent.

The same can be observed for the following kodak images.

Kodak26:

Kodak original image



Kodak noisy image for $\sigma = 5$

Mean shift Filtering:

Filtered kodak image with $\sigma_s = 0.1,\ \sigma_r = 0.1$

Filtered barbara image with $\sigma_s = 2,\ \sigma_r = 2$

Filtered kodak image with $\sigma_s = 3,\ \sigma_r = 15$

$\sigma = 10$

Barbara256:

Barbara original image

Barbara noisy image for $\sigma = 10$

Mean shift Filtering:

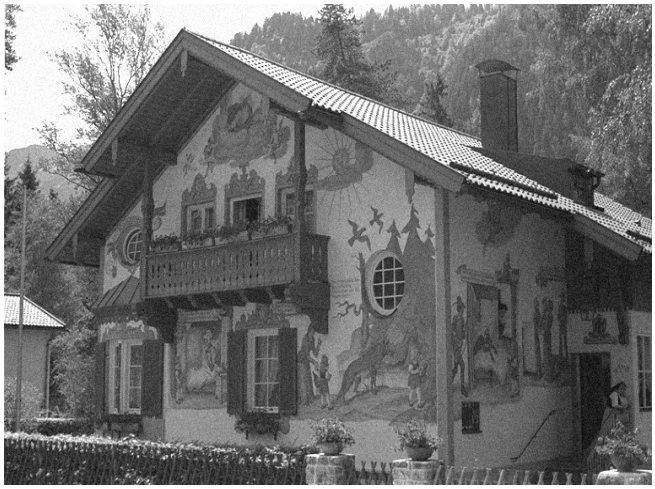
Filtered barbara image with $\sigma_s = 0.1,\ \sigma_r = 0.1$

Filtered barbara image with $\sigma_s = 2,\ \sigma_r = 2$

Filtered barbara image with $\sigma_s = 3,\ \sigma_r = 15$

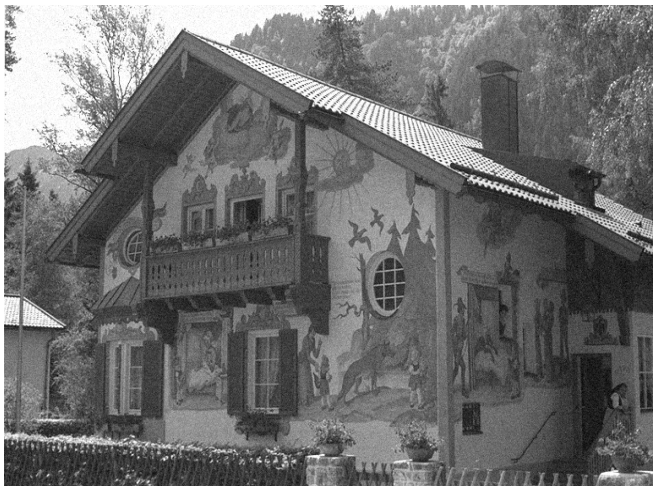
Kodak26:

Kodak original image

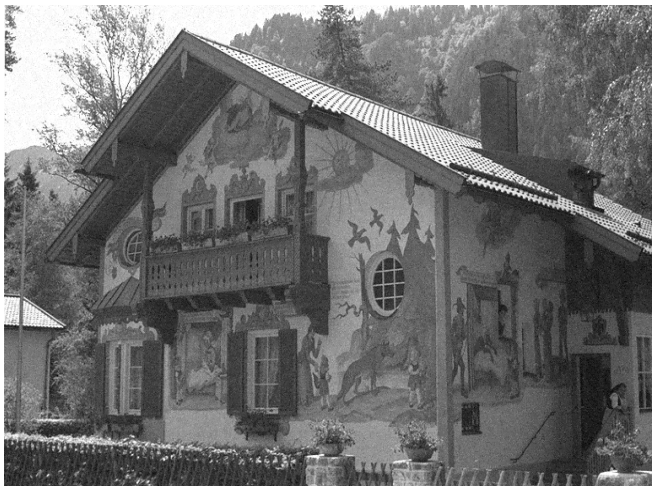


Kodak noisy image for $\sigma = 10$

Mean shift Filtering:



Filtered kodak image with $\sigma_s = 0.1,\ \sigma_r = 0.1$



Filtered barbara image with $\sigma_s = 2,\ \sigma_r = 2$

Filtered kodak image with $\sigma_s = 3,\ \sigma_r = 15$

As we increase the standard deviation of gaussian noise, the intensities have more error now. We observed the convergence time has reduced compared to the previous case and we could observe the filtering effects more clearly now.