CS 663, Fall 2023

Assignment 3

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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.

Solution:

Figure 1 shows the original image as well as noisy image of Barbara with zero-mean Gaussian noise standard deviation $\sigma = 5$.

(a) Barbara original images

(b) Noisy Barbara $\sigma = 5$

Figure 1: Barbara

Figure 2 shows the output of a mean shift based filter the parameter configurations: ($\sigma_s = 2$, $\sigma_r = 2$); ($\sigma_s = 0.1$, $\sigma_r = 0.1$); ($\sigma_s = 3$, $\sigma_r = 15$) with zero-mean Gaussian noise standard deviation $\sigma = 5$.

Figure 3 shows the original image as well as noisy image of Kodak with zero-mean Gaussian noise standard deviation $\sigma = 5$.

Figure 4 shows the output of a mean shift based filter the parameter configurations: ($\sigma_s = 2$, $\sigma_r = 2$); ($\sigma_s = 0.1$, $\sigma_r = 0.1$); ($\sigma_s = 3$, $\sigma_r = 15$) with zero-mean Gaussian noise standard deviation $\sigma = 5$.

Figure 5 shows the original image as well as noisy image of Barbara with zero-mean Gaussian noise standard deviation $\sigma = 10$.

Figure 6 shows the output of a mean shift based filter the parameter configurations: ($\sigma_s = 2$, $\sigma_r = 2$); ($\sigma_s = 0.1$, $\sigma_r = 0.1$); ($\sigma_s = 3$, $\sigma_r = 15$) with zero-mean Gaussian noise standard deviation $\sigma = 10$.

Figure 3 shows the original image as well as noisy image of Kodak with zero-mean Gaussian noise standard deviation $\sigma = 10$.

Figure 4 shows the output of a mean shift based filter the parameter configurations: ($\sigma_s = 2$, $\sigma_r = 2$); ($\sigma_s = 0.1$, $\sigma_r = 0.1$); ($\sigma_s = 3$, $\sigma_r = 15$) with zero-mean Gaussian noise standard deviation $\sigma = 10$.

Conclusion:

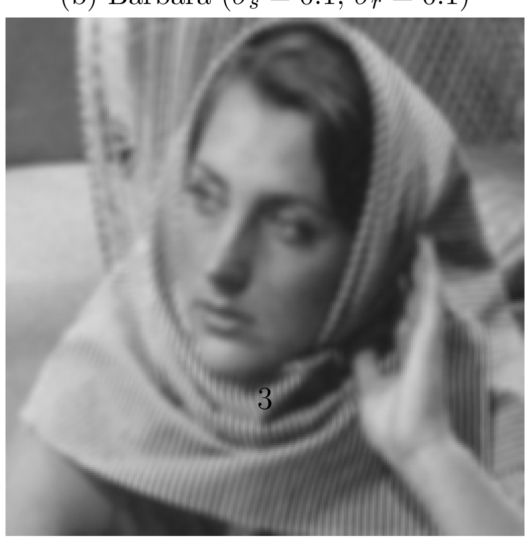
We have seen that for $\sigma_s = 0.1$, $\sigma_r = 0.1$ filtered image has no changes it is quite same as original image but for ($\sigma_s = 2$, $\sigma_r = 2$) there are very few regions which are smoothened and in case of ($\sigma_s = 3$, $\sigma_r = 15$) there is more smootheness than other two cases.

For higher values of σ_s and σ_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 σ_s, or values because with fewer local maximas, a pixel is at more distant to reach through gradient ascent. The same can be observed for the kodak images.

As we increase the value of σ, here we have increased as by 5, the error in intensity increases. Also the convergence time also reduce.

(a) Barbara ($\sigma_s = 2$, $\sigma_r = 2$)

(b) Barbara ($\sigma_s = 0.1$, $\sigma_r = 0.1$)



(c) Barbara ($\sigma_s = 3$, $\sigma_r = 15$)

Figure 2: **Mean shift based filtering on Barbara with** $\sigma = 5$

(a) Kodak original images

(b) Noisy Kodak $\sigma = 5$

Figure 3: Kodak

(a) Kodak ($\sigma_s = 2$, $\sigma_r = 2$)

(b) Kodak ($\sigma_s = 0.1$, $\sigma_r = 0.1$)

(c) Kodak ($\sigma_s = 3$, $\sigma_r = 15$)

Figure 4: **Mean shift based filtering on Kodak with** $\sigma = 5$

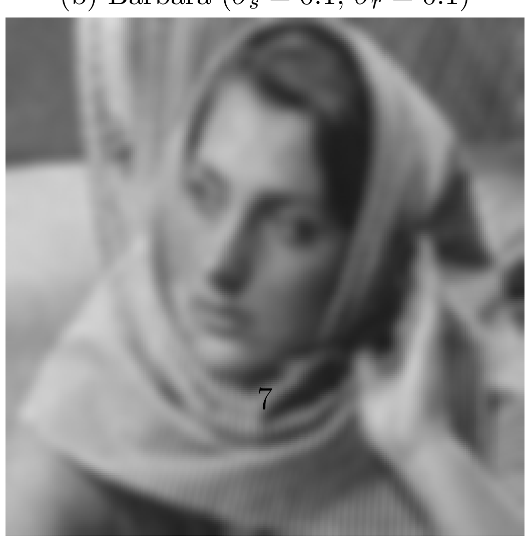
(a) Barbara original images

(b) Noisy Barbara $\sigma = 10$

Figure 5: Barbara

(a) Barbara ($\sigma_s = 2$, $\sigma_r = 2$)

(b) Barbara ($\sigma_s = 0.1$, $\sigma_r = 0.1$)



(c) Barbara ($\sigma_s = 3$, $\sigma_r = 15$)

Figure 6: **Mean shift based filtering on Barbara with** $\sigma = 10$

(a) Kodak original images

(b) Noisy Kodak $\sigma = 10$

Figure 7: Kodak

(a) Kodak ($\sigma_s = 2$, $\sigma_r = 2$)

(b) Kodak ($\sigma_s = 0.1$, $\sigma_r = 0.1$)

(c) Kodak ($\sigma_s = 3$, $\sigma_r = 15$)

Figure 8: **Mean shift based filtering on Kodak with** $\sigma = 10$