EE5175: Image Signal Processing - Lab 13 report

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1 Wiener filtering

Aim: To perform Wiener filtering for the given image `lena.jpg` by treating the term S_{nn}/S_{ff} as a constant **k**. The degradation is assumed to be a Gaussian blur of standard deviation $\sigma_b = 1.5$ and AWGN noise of standard deviations (σ_n): 1, 5 and 15. Also, to find the **k** value corresponding to the least RMSE error for each noise variance value.

Input image (Lena)

2 Wiener filtering algorithm:

Let $f(x, y)$ be the input image which is degraded by a LSI kernel $h(x, y)$ and corrupted by an AWGN noise $n(x, y)$ to produce the degraded output $g(x, y)$:

$$g(x, y) = h(x, y) * f(x, y) + n(x, y)$$

where $'*'$ denotes 2D convolution. Let us denote the 2D power spectral density of the input image $f(x, y)$ as $S_{ff}(m, n)$ and that of the noise as $S_{nn}(m, n)$. Let the 2D DFT of the kernel be $H(m, n)$ and that of the degraded image be $G(m, n)$. Then according to the Wiener filtering method, the DFT coefficients of the output image are given as:

$$\hat{F}(m, n) = \frac{H^*(m, n)}{|H(m, n)|^2 + \frac{S_{ff}(m,n)}{S_{nn}(m,n)}} G(m, n)$$

where A^* denotes complex conjugate of A.

Typically, the term $\frac{S_{ff}(m,n)}{S_{nn}(m,n)}$ is assumed to be a constant **k** which is hand-tuned to get the least RMSE error between the estimated image and the actual image. In this assignment, k is varied from 0.01 to 2.0 in steps of 0.001 and the k value corresponding to the least RMSE for each σ_n is obtained.

3 Results on the given image:

Using the given clean image, σ_b and σ_n values, degraded, noisy versions of the image were created. Wiener filtering was applied on these images using different k values and the results corresponding to min. RMSE values are given below:

For $\sigma_n = 1$

For $\sigma_n = 5$

For $\sigma_n = 15$

The corresponding k values giving min. RMSE are: **0.01, 0.024** and **0.062**. The images are sharp but as σ_n increases, the effect of the noise is more prominent as expected.

4 Observations and Conclusions

1. Wiener filtering has effectively removed the blur present in the degraded image. However, the effect of noise is still present for high σ_n values.
2. NLM filtering can be used on these outputs to remove the effect of noise without compensating for the sharpness of the image.