EE5175: Image Signal Processing

Wiener Filter

Q1. For the given image `lena.png`, perform Wiener filtering based image restoration (by treating the term $\frac{S_{nn}}{S_{ff}}$ as a constant) for the following scenarios (σ_n - Gaussian noise σ, σ_b - Gaussian blur σ) :

- $\sigma_n = 1$, $\sigma_b = 1.5$
- $\sigma_n = 5$, $\sigma_b = 1.5$
- $\sigma_n = 15$, $\sigma_b = 1.5$

NOTE: In the Wiener filter expression $\frac{\mathbf{H}^*}{\mathbf{H}^*\mathbf{H} + \frac{S_{nn}}{S_{ff}}}$, treat the term $\frac{S_{nn}}{S_{ff}}$ as a constant (say, k, i.e., $\frac{\mathbf{H}^*}{\mathbf{H}^*\mathbf{H} + k}$) and vary it from 0.01 to 2.0 in steps of 0.001. For each case, pick the k that gives minimum RMS error between the original image and the estimated image.

Q2. For the given image `lena.png`, perform Wiener filtering based image restoration (by treating the term S_{nn} as a constant) for the following scenarios (σ_n - Gaussian noise σ, σ_b - Gaussian blur σ) :

- $\sigma_n = 1$, $\sigma_b = 1.5$
- $\sigma_n = 5$, $\sigma_b = 1.5$
- $\sigma_n = 15$, $\sigma_b = 1.5$

NOTE: In the Wiener filter expression $\frac{\mathbf{H}^*}{\mathbf{H}^*\mathbf{H} + \frac{S_{nn}}{S_{ff}}}$, treat the term S_{nn} as a constant (say, k, i.e., $\frac{\mathbf{H}^*}{\mathbf{H}^*\mathbf{H} + \frac{k}{S_{ff}}}$) and vary it to find the most visually pleasing output. For each case, find the average power spectrum of a number of randomly selected natural images to obtain an approximation to S_{ff}, as explained next.

To compute S_{ff} : Get around 100 images from internet. Convert all images to gray scale and re-size them to the same size as that of the input image (`lena.png`). Let $\mathbf{F}_i$ be the 2D DFT of i^{th} image from the whole collection of re-sized images. Compute the average power spectrum from all re-sized image as follows.

$$S_{ff} = \frac{1}{100}\sum_{i=1}^{100} \mathbf{F}_i^* \mathbf{F}_i \tag{1}$$

where the multiplication in $\mathbf{F}_i^*\mathbf{F}_i$ is an element-wise multiplication. To perform Wiener filtering, use the following form of filter equation.

$$\frac{\mathbf{H}^* S_{ff}}{\mathbf{H}^*\mathbf{H}S_{ff} + k} \tag{2}$$

where all the multiplications and divisions involved are element-wise multiplications and divisions.

Q3. (Optional) Compute S_{ff} similar to the **Q2**, but with all the images from the class of face images. Download the data-set available in `fei.edu.br/~cet/originalimages_part1.zip` and use

100 frontal face images from that dataset for computation of S_{ff}. For the given image `face.jpg`, perform Wiener filtering based image restoration (by treating the term S_{nn} as a constant) for the following scenarios (σ_n - Gaussian noise σ, σ_b - Gaussian blur σ) :

- $\sigma_n = 1$, $\sigma_b = 1.5$
- $\sigma_n = 5$, $\sigma_b = 1.5$
- $\sigma_n = 5$, motion blur (use the kernel `kernel.png`)