EE5175: Image Signal Processing

Lab-10

Non-local Means Filtering

In this experiment, we will implement non-local means (NLM) filtering algorithm for the application of denoising.

You are given a noisy image, $\mathbf{g}$ (`krishna_0_001.png`), corresponding to a latent image, $\mathbf{f}$ (`krishna.png`), corrupted with additive Gaussian noise of mean 0 and variance 0.001. Your task is to apply NLM filtering on $\mathbf{g}$ following the steps in the given pseudocode to arrive at the denoised image, $\hat{\mathbf{f}}$.

The parameters of the algorithm are the search neighbourhood radius W , the similarity neighbourhood radius W_{sim} and the filter parameter σ_{NLM} . A radius of W at a pixel denotes a window size of $(2W + 1) \times (2W + 1)$ around that pixel. The same applies to W_{sim}.

Q1. Show plots between the PSNR between $\mathbf{f}$ and $\hat{\mathbf{f}}$ (y-axis) for different NLM filter parameter values $\sigma_{NLM} = 0.1$ to 0.5 in steps of 0.1 (x-axis) for the following search radius and similarity radius settings:

(a) $W = 3, W_{sim} = 3$,

(b) $W = 5, W_{sim} = 3$.

Show two plots in the same window with two different colours corresponding to (a) and (b). Compare the PSNR plots with the baseline PSNR between the noisy image $\mathbf{g}$ and the latent image $\mathbf{f}$.

Q2. We will now compare NLM filtering with the traditional Gaussian filtering. Denoise $\mathbf{g}$ using space-invariant Gaussian filter with $\sigma_g = 0.1$ to 0.5 in steps of 0.1 having a kernel window size of 7×7 for all σ_g values. Calculate the PSNR between the denoised images and $\mathbf{f}$. Add this plot to the plot window in **Q1**.

For the following filtering settings: (a) $W = 5, W_{sim} = 3, \sigma_{NLM} = 0.5$ for the NLM filtering, and (b) $\sigma_g = 1.0$ for Gaussian filtering, and at the following pixel locations $\mathbf{p}$: (i) row = 31, column = 46, and (ii) row = 38, column = 58, (total four combinations), do **Q3** and **Q4**.

Q3. Show the 11 11 filter (kernel) as an image.

Q4. Show the 11 11 image patch from the noisy image and the denoised images.

Note:

The general formula for PSNR is 10*log10(MAX*MAX / MSE), where MAX is the maximum image intensity value. We use MAX=255 in this experiment.