Multimedia Telecommunications

Exercise Session 6

Exercise 1: Wavelet based denoising

For the image `einstein.jpg`

1. Add zero-mean Gaussian white noise with increasing PSD (power spectral density). Choose the noise parameters (μ, σ) such that the noise is visible also with the lowest PSD.

2. Calculate the PSNR and the MSE between the original the noisy image

$$PSNR = 20 \log_{10} \frac{255}{\sqrt{MSE}} \quad (1)$$

$$MSE = \frac{\sum_i \sum_j (im1[i,j] - im2[i,j])^2}{N_x N_y} \quad (2)$$

3. Perform the DWT and the Stationary Wavelet Transform (SWT) on the noisy images with the following parameters:

Number of levels	J=3, 4
Filters	biorthogonal 2.2, d4, sym8

4. Threshold the coefficients of each resulting subband following the hard and soft thresholding methods. Set the threshold value to (1) $T = \sigma\sqrt{2 \ln N}$; (2) $T^0_{j,k} = \sigma_{j,k}$ and (3) $T^1_{j,k} = \sigma_{j,k}\sqrt{2 \ln N_{j,k}}$, where $j = 1, \ldots, 3$ is the decomposition level, k selects the orientation, σ is the standard deviation of the image, N is the number of pixels in the image, $\sigma^2_{j,k}$ is the variance of subband j, k and $N_{j,k}$ is the number of samples in subband j, k.

5. For each condition, reconstruct the image and calculate the PSNR;

6. Plot the PSNR of the noise and denoised images with respect to the reference image as a function of the noise PSD.

   Was the denoising effective?