ECE 533 FALL 2015 LAB 3
IMAGE NOISE REMOVAL

We have discussed several methods for removing noise from images, including:

- low-pass filters,
- median filters,
- bilateral filters,
- nonlocal means,
- BM3D,
- thresholding Fourier coefficients, and
- thresholding wavelet coefficients.

In this mini-project, you will compare the performances of these different approaches on a test image of your choice at various levels of noise.

1. Write a script to compute the Haar wavelet transform of an image. Write a script to compute the inverse Haar wavelet transform of an image.
2. Generate a noisy version of your test image in MATLAB, where the noise is Gaussian with variance σ^2 a parameter you choose. For each noise level σ^2, you'll need to generate and denoise 10 different realizations of the noisy image and average the mean squared errors to get a sense of the average-case performance. Compare different denoising methods:
   (a) Denoise the noisy image using a Gaussian LPF, with several different choices of filter bandwidth and neighborhood size.
   (b) Denoise the noisy image using a median filter with several different neighborhood sizes.
   (c) Denoise the noisy image using a bilateral filter with several different neighborhood sizes.
   (d) Denoise the noisy image using nonlocal means with several different patch sizes.
   (e) Denoise the noisy image using BM3D-lite with several different neighborhood sizes.
   (f) Denoise the noisy image using Fourier coefficient thresholding with several different threshold levels.
   (g) Denoise the noisy image using wavelet denoising with several different threshold levels.
   (h) (Optional bonus task: denoise the noisy image using adaptive filtering as described in the textbook.)
   (i) Plot the MSE of all methods for 10 different values of noise variance, σ^2.

(j) Comment on your results. Which approaches seem to work best? Which work worst? Are there cases where the lowest MSE estimate is not necessarily the best looking? What can you say about your newly designed denoising method?

3. Repeat the above for impulse noise (aka salt and pepper noise) for 10 different noise density levels d. See "imnoise" in matlab for generating this noise in your image.

You may use either MATLAB or Python for this and all coursework. However, examples will be provided in MATLAB.

A. Deadline

Reports, including images, descriptions, and code, should be turned in via Moodle. Turn in the result of "publish" in Matlab or iPython Notebooks. Written problem solutions should also be submitted digitally. If you photograph or scan hand-written solutions, make sure they are legible. Due by 2:30pm on Oct. 12.