RE50900 - DIPCV - Assignment III

Frequency Analysis and Restoration

- **Requirements**: The requirements of each assignment of this course at least include a) full document in PDF/Word format with implementation details and difficulties you met, 2) source code and the compiled file (in exe/dmg/sh) and its readme to indicate how to launch it, and 3) key comments in your source code. If your code was referred from an existing source on the Internet, please cite it accordingly. Note that the packages CAN NOT be used in this assignment except the visualization functions.

- **Problem set (110pt):**

  Dataset: Lena.raw/Baboon.raw/F16.raw/Noisy.raw

  1. **(24pt) Fourier Transform**: Give test images with the RAW format, please transform the images to the frequency domain using DFT. Note that in the visualized parts you can only use the real part and ignore the imaginary part.

     i. Based on DFT, please draw the frequency response without shitting, where the lower-frequency will be located at four corners.

     ii. Please show the centralized result based on (i).

     iii. Plot the histogram of the spectrum, and make a discussion on high- and low-frequency components for Baboom, F16, and Noisy.raw, respectively. The x-axis does not require an explicit representation for the frequency unit. You can assign the left part as the lowest frequency for example.

  2. **(24pt) Low-pass filter**: Based on Lena/Baboon, and F16.raw, please follow the following instructions:

     i. Make a Random Noise generator (uniform and Gaussian with specific mean/var) to add the noise to the original images in Spatial Domain.

     ii. Apply the ideal low-pass filter to obtain the denoised results with different settings (determined by yourself).

     iii. Apply the Gaussian low-pass filter to obtain the denoised results with different settings (determined by yourself).

  3. **(10pt) High-pass filter**: Use all of the test images as the test samples. Please use the ideal and Butterworth high-pass filters. Make a comparison between the frequency high-pass filter and the Laplacian filter (spatial one).

4. **(32pt) Image denoising**: Give the noise.raw, please adopt the following schemes to remove the noise as clean as possible. Also, please simply describe how it works and how to choose the parameters if any.

    i. Inverse filter

    ii. Wiener filter

    iii. BM3D [1]

    iv. Guided Filter [2]

5. **(20pt) DCT as the image restoration domain**: We usually adopt DFT to transform the spatial domain to the frequency domain. By analyzing the frequency component, we can remove some specific patterns (e.g., noise). Now please design a DCT-based denoiser for noisy.raw image. Please adopt a full-size DCT transform instead of an 8x8 DCT block transform. Please also design a filter that can work well in the DCT domain.

References:

1. *Dabov, Kostadin, et al. "Image denoising by sparse 3-D transform-domain collaborative filtering." IEEE Transactions on image processing 16.8 (2007): 2080-2095.*
2. *He, Kaiming, Jian Sun, and Xiaoou Tang. "Guided image filtering." European conference on computer vision. Springer, Berlin, Heidelberg, 2010.*