Image Processing (NCTU, Fall 2019)
Programming Assignment #3 (due 1/7/2020)

The objective of this project is for you to implement lossy image compression and study the effects of various methods and parameter choices. The coding scheme to use is similar to part of JPEG. (The complete JPEG standard includes several stages and options. With our time limit, it is not necessary to implement everything. We will focus on transform coding and quantization, as explained below.)

Required Tasks:

- Implement two-dimensional WHT, DFT, and DCT for gray-scale images. Design your code such that you can generate the transforms for different block sizes. (Note: No zero-padding here.)
- Select a few images with different levels of spatial details, and apply your implemented transforms at different block sizes. (Note: Since most source images are already JPEG coded, in order to prevent the effects of the original coding from affecting your experiments, try to start with very high resolution images (for example, 3840x2160), down-sample them to smaller sizes (for example, 640x360), and use the smaller images as the "source images" for your experiments.)
- Analyze the variances of all the transform coefficients to compare the "information packing" abilities of the different transforms. Also compare the results for different images.
- Implement several different quantization schemes:
  - Keep only the first k coefficients.
  - Keep only the coefficients with the k largest coefficients.
  - Distribute a fixed number of bits to all the coefficients according to the logarithm of coefficient variances. Note: Some coefficients may get zero bits, meaning they are effectively discarded.
- Use eRMS and SNR to evaluate the reconstructed images in different settings (transform type, block size, quantization method, quantization strength). Also check whether the results are consistent with what you see from the analysis of information packing abilities.
- Try to do qualitative comparisons of the reconstructed images. For this purpose, you need to zoom in to small parts of the images, much like examples given in the textbook/slides.

Optional Tasks:

- Try your transforms with color images. The transforms can be applied to either the RGB channels or the YCbCr channels. Are the results different? What if you use the "distances between colors" in the LAB color space for evaluation? (For this task, it is ok to use the color-space transform functions available in your programming environment.)

The rules about allowed programming environments, limitations on the usage of library functions or external codes, and the submission of your report are the same as those given in the first programming assignment. You can reuse whatever functions you have implemented for the previous assignments.