CS3570 Introduction to Multimedia Technology

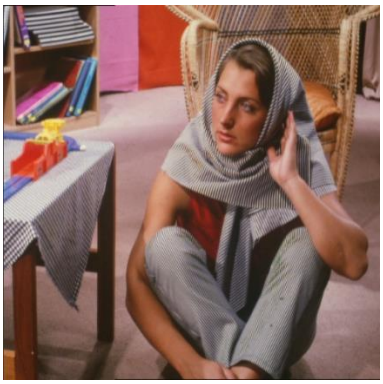
Homework #2

Due: 11:59pm, 4/11/2025

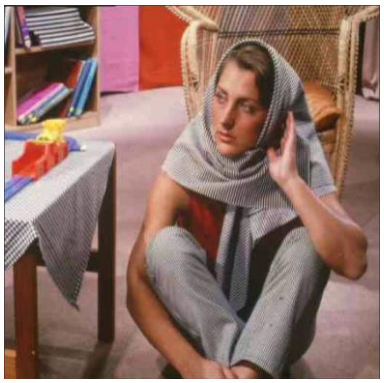
1. DCT image compression (40%)

Transform the image "*Barbara.jpg*" from spatial domain to frequency domain with DCT for compression and quantize the frequency values with different quality factor. Then, reconstruct the compressed image using inverse DCT. Please following the steps given below:

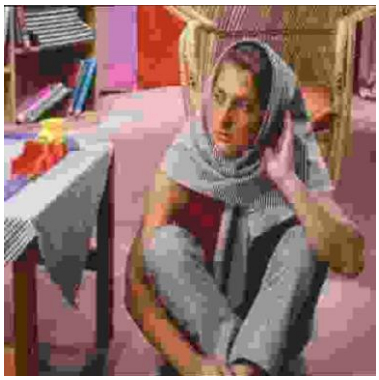
1. Implement RGB to YCbCr and chrominance subsampling (4:2:0) to convert the original image into luminance and chrominance components.
2. Divide the Y, Cb, Cr channels into 8x8 blocks.
3. Shift values by -128 and transform the each 8x8 blocks from spatial domain to the DCT domain.
4. Apply quantization on frequency values with suitable quantization table.
5. Reconstruct the image by taking inverse discrete cosine transform (IDCT) and shift values by +128.
6. Reassemble the Y, Cb, Cr channels from 8x8 blocks.
7. Upsample Cb, Cr and convert YCbCr back to RGB.
8. Compute the PSNR score with reconstruct images and the original image.



Original image



Compressed image (Qf=30)



Compressed image (Qf=5)

2. Create your own FIR filters to filter audio signal (40%)

"*HW2_Mix.wav*" is a mix of 3 songs. Based on the ideal impulse responses given in *slide #72* and the windowing functions in *slide #75*, you need to design and apply different FIR filters in time domain to separate the three audio signals from the given audio file. You can refer to the algorithm on *slide #76*. Next, you are asked to reduce the sampling rates of signals and compare them. Finally, the output audio signals are too simple so you should apply one-fold echo and multiple-fold echo (*slide #69*) to produce wonderful music. Please following the steps given below:

1. Transform the input signal into frequency domain.
2. Implement 3 different FIR filters to separate the three audio signals with Blackmann window function (You have to pick the appropriate window size and cut-off frequency). Please Implement 1-D convolution on the input signal of the given audio with your filters.
3. Reduce the sampling rates of the three separated songs to 2000Hz.
4. Apply one-fold echo and multiple-fold echo on the audio signal that pass through the low-

pass filter. (Please use the audio files before reducing sampling rates)

For question2 you need to turn:

(a) Image results [10 images]:

1. The spectrum of the input signal.
2. The spectrums of the output signals. (Before echo.) [3 images]
3. The spectrums of the filters. [3 images]
4. The shapes of the filters (time domain) [3 images]

(b) Audio results:

1. Store the three filtered audio files before reducing the sampling rates. "Low_pass_[cutoff frequency].wav". "High_pass_[cutoff frequency].wav". "Band_pass_[cutoff frequency 1]_[cutoff frequency 2].wav".
2. Store the three filtered audio files after reducing the sampling rates. "Low_pass_[cutoff frequency]_2kHZ.wav". "High_pass_[cutoff frequency]_2kHZ.wav". "Band_pass_[cutoff frequency 1]_[cutoff frequency 2] _2kHZ.wav".
3. Store the echo audio files and name "Echo_one.wav" and "Echo_multiple.wav".

3. Report (20%)

1. DCT compression
   - Describe how you implemented the discrete cosine transform.
   - Why should we convert image from RGB to YCbCr before compressing?
   - Explain how can the quality factor affects the compression result.
2. FIR Filter
   - How you implement the filter and convolutions to separate the mixed song. And how did you determine the filter size and cutoff frequency.
   - Compare spectrum and shape of the filters.
   - Compare the difference between signals before and after reducing the sampling rates.

Reminder

- You are Not Allowed to import any library in your Jupyter Notebook file, except for those provided by us.
- Your code must display and output your results to enable us to verify its correctness.
- Please follow the instructions in the Jupyter Notebook and complete the parts marked as "TODO".
- If you encounter any problem or have questions, please post them on eeclass.
- Please compress your Jupyter Notebook file, image results from Q1, audio results from Q2 in a zip file named HW2_xxxxxxxxx_ooo.zip, where xxxxxxxxx is your student ID and ooo is your name.
- Homework should be submitted before the announced due time. Scores of late submission will be reduced by 20% per day.