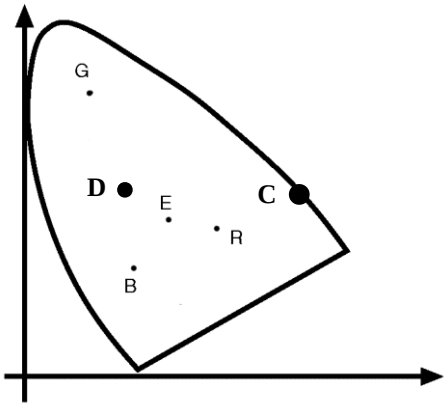
CS576 Assignment 2
Instructor: Parag Havaldar
Assigned – 09/26/2016
Solutions due – 10/17/2016 by noon

Color Theory – 20 points

One of uses of chromaticity diagrams is to find the gamut of colors given the primaries. It can also be used to find dominant and complementary colors –

Dominant color of a given color D (or dominant wavelength in a color D) is defined as the spectral color which can be mixed with white light in order to reproduce the desired D color. *Complementary colors* are those which when mixed in some proportion create the color white. Using these definitions and the understanding of the chromaticity diagram that you have, answer the following.



- In the image alongside find the dominant wavelength of color D. Show this wavelength.
- Do all colors have a dominant wavelength? Explain your reasoning.
- Find the color which is complimentary to the color C and plot its location. What colors in the three dimensional RGB color space map to the equiluminous point E upon projection into the 2D chromaticity space.

Generic Compression – 30 points

Consider a communication system that gives out only two symbols X and Y. Assume that the parameterization followed by the probabilities are $P(X) = x^2$ and $P(Y) = (1-x^2)$.

- Write down the entropy function and plot it as a function of x.
- From your plot, for what value of x does the Entropy become a minimum?
- Although the plot visually gives you the value of x for which the entropy in minimum, can you now mathematically find out the value(s) for which the entropy is a minimum?
- Can you do the same for the maximum, that is can you find out value(s) of x for which the value is a maximum?

Image Dithering – 50 points

Let's say that we have an original 12x8 image represented as 8 bits per pixel. In the normalized representation shown below, assume that 0 corresponds to white and 9 corresponds to black.

1	2	3	4	5	6	7	8	9	0	1	2
0	1	2	3	4	5	6	7	8	9	0	1
9	0	1	2	3	4	5	6	7	8	9	0
8	9	0	1	2	3	4	5	6	7	8	9
7	8	9	0	1	2	3	4	5	6	7	8
6	7	8	9	0	1	2	3	4	5	6	7
5	6	7	8	9	0	1	2	3	4	5	6
4	5	6	7	8	9	0	1	2	3	4	5

Answer the following questions. You may have to code/script a process to generate the final outputs, but only final outputs are expected.

- Plot the image and make sure that you submit a "zoomed" in image which properly shows all image gray values.
- Compute the output of a dithering operation using the dithering matrix D given below. Assume that the image top left coordinate indexes are [0, 0]. Show a graphical binary image plot of the dithered output.

$$D = \begin{bmatrix} 6 & 8 & 4 \\ 1 & 0 & 3 \\ 5 & 2 & 7 \end{bmatrix}$$

- What if the image block's top left coordinate indexes start with [1, 1]. Show a graphical binary image plot of the dithered output.

Programming Assignment 100 points

In this programming assignment you are asked to implement a JPEG like compression algorithm. You will have to start with an RGB image file. Images will be kept on the class website. We have given you starter code to read an image and display it as two images, left which is the input and right which is the same as input, but your program will process it and come with an output.

Your program will take as input two parameters

- The input RGB file

- The number *n* of diagonal row of coefficients to use. The diagonal rows are indexed in a zig zag scan order.
  n = 1 implies only the first diagonal which has the [DC] coefficient.
  n = 2 implies the first and second diagonals containing [DC], [AC_1 AC_2]
  n = 3 implies the first three diagonals containing [DC], [AC_1 AC_2], [AC_3 AC_4 AC_5]
  …

Here are some example invocations:

MyProgam.exe inpuFile.rgb 1

This case converts your image to the DCT domain for all channels and uses only the DC coefficients to convert it back to the spatial domain. Consequently, the output should appear very blocky.

MyProgam.exe inpuFile.rgb 15

This case converts your image to the DCT domain and uses all coefficients (since there are 15 diagonal rows overall) to convert it back to the spatial domain. Consequently, the output should be the same as input with no loss.

MyProgam.exe inpuFile.rgb 8

This case converts your image to the DCT domain and using the upper left triangular set of 36 coefficients (since 8 rows correspond to 1+2+3+4+5+6+7+8 = 36 coefficients) to convert it back to the spatial domain. Consequently, the output should be the same as input with no loss.

Implementation Details

Implement psuedo-jpeg compressor/decompressor where,

1. Convert the image to YPrPb using the following matrix

$$\begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y [0 ... 255]
Pb/Pr [-127.5 ... +127.5]

www.equasys.de

RGB to YPbPr color conversion for SDTV

2. Break all channels into 8x8 blocks
3. For each block, do a DCT on the blocks to compute the DC and AC coefficients.
4. Keep the first n diagonal rows of coefficients as suggested by the input parameter and zero out the rest of the coefficients
5. Do an Inverse DCT on the quantized AC and DC coefficients to recover the image signal in the YPrPb space.

6. Convert the image back to RGB space using the matrix conversion below and display the output

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.402 \\ 1.000 & -0.344 & -0.714 \\ 1.000 & 1.772 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix}$$

Ranges:
Y [0 ... 255]
Pb/Pr [-127.5 ... +127.5]
R/G/B [0 ... 255]

www.equasys.de

YPbPr to RGB color conversion for SDTV

What you have to turn in –
***Please submit only source code*.**
The TA/grader will compile your program and run it by
"yourassignment.exe imagefile.rgb N",.
The program upon execution must show two images – the original uncompressed image and the image after compression/decompression depending on this value of N.
Remember, if your code cannot be compiled or causes errors while running, we will not be able to assess the quality of your output results.