SE 461 Computer Vision – Assignment 1

Dr. Nazar Khan

November 10, 2014

Due Date: Monday, 17th November, 2014 before class.

Colour Spaces

1. Write a MATLAB function called **myRGBtoYCbCr** to convert an image from RGB space to YCbCr space.

$$\begin{pmatrix} Y \\ Cb \\ Cr \end{pmatrix} = \begin{pmatrix} 0 \\ 127.5 \\ 127.5 \end{pmatrix} + \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

2. Write a MATLAB function called **myYCbCrtoRGB** to convert an image from YCbCr space to RGB space.

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} 1.000 & 0.000 & 1.403 \\ 1.000 & -0.344 & -0.714 \\ 1.000 & 1.773 & 0.000 \end{pmatrix} \left(\begin{pmatrix} Y \\ Cb \\ Cr \end{pmatrix} - \begin{pmatrix} 0 \\ 127.5 \\ 127.5 \end{pmatrix} \right)$$

3. Write a MATLAB function called **mySubsample** to subsample a 2D matrix by a given factor S. (S will be the input to your function).

4. Write a MATLAB function called **myUpsample** to upsample a 2D matrix by a given factor S. (S will be the input to your function).

5. Write a MATLAB function called **chromaticCompression** that converts an input RGB image, converts it to YCbCr, then subsamples the chromatic channels (Cb and Cr) by a factor S, then upsamples the chromatic channels (Cb and Cr) by a factor S and converts the resulting YCbCr image back to RGB space and outputs this result.

6. For **baboon.png**, compute results of your function **chromaticCompression** for $S = 2, 4, 8$ and 16. For each value of S, the resulting image should be stored as **baboon$S$.png**. What do you observe visually?

7. **(Non-programming)** An RGB image needs 24 bits to store each pixel. Why 24 bits?

8. **(Non-programming)** How many bits-per-pixel are required to store the YCbCr images directly for $S = 2, 4, 8$ and 16?

Convolution

1. Write a MATLAB function **my2DConvolution** for convolving a 2D grayscale image I with a 2D convolution mask M. Your function should place the mask only at those pixels where the complete mask fits inside the image.

2. Convolve **baboon.png** with the following mask

$$M_{3\times3} = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

   Store the resulting image as **baboonM3x3.png**.

3. **(Non-programming)** For a single pixel at (x, y), what operation does convolution with $M_{3\times3}$ perform?

4. **(Non-programming)** What would $M_{5\times5}$ look like?

5. Convolve **baboon.png** with $M_{9\times9}$. Store the resulting image as **baboonM9x9.png**. Compare with **baboonM3x3.png**. What do you observe?

6. **(Non-programming)** How many multiplications and additions are performed for

   (a) convolution with $M_{3\times3}$ at a single pixel?

   (b) convolution with $M_{3\times3}$ for an image of size $m \times n$?

   (c) convolution with $M_{9\times9}$ for an image of size $m \times n$?

7. **(Non-programming)** How many multiplications and additions are performed for

   (a) convolution with $M_{3\times1}$ at a single pixel?

   (b) convolution with $M_{3\times1}$ for an image of size $m \times n$?

   (c) convolution with $M_{3\times1}$ for an image of size $m \times n$ **followed by** convolution of the resulting image with $M_{1\times3}$?

   (d) Convolution is a separable operation, *i.e.*, $I * M_{3\times3} = (I * M_{3\times1}) * M_{1\times3}$. Which way should convolution be performed practically – $I * M_{3\times3}$ or $(I * M_{3\times1}) * M_{1\times3}$? Why?

Submission

This assignment is to be done in groups of 3 students each. **It is highly recommended that you try this assignment individually at first and then combine your results.** Email your assignment to the TA Nausheen Qaiser at **phdcsf13m005@pucit.edu.pk** as a .zip file with the naming convention

`RollNumber1_RollNumber2_RollNumber3_YourName_Assignment1.zip`

For example, if roll numbers of your group members are BSEF11M997, BSEF11M998 and BSEF11M999, then the .zip file should be named

`BSEF11M997_BSEF11M998_BSEF11M999_Assignment1.zip`

The .zip file should contain the following directories:

- **ColourSpaces**
- **Convolution**

The **ColourSpaces** directory should contain the following:

1. MATLAB code (.m files) for all programming problems 1–5.
2. The images baboon2.png, baboon4.png and baboon8.png.
3. A .txt file called README.txt containing
   (a) your observations for problem 5 regarding baboon2.png, baboon4.png and baboon8.png.
   (b) your answers to problems 6 and 7.

The **Convolution** directory should contain the following:

1. MATLAB code (.m file) for programming problem1.
2. The images baboonM3x3.png and baboonM9x9.png.
3. A .txt file called README.txt containing
   (a) your answers to problems $3, 4, 6$ and 7.
   (b) your observations for problem 5 regarding baboonM3x3.png and baboonM9x9.png.

Please do not submit a very large .zip containing extra files. It should only contain what is asked for.