CS-111: Written Assignment 2

Submission instructions:

Submit your answers to the following questions in a single pdf file on Canvas & Gradescope. Your work is due by **11:59 p.m. on Wednesday, the 22nd of May**.

Questions:

1) Suppose that a 3-bit image has the intensity distribution shown in the Table-1, where intensity levels are integers in the range [0,7]. What is the new intensity distribution after applying histogram equalization/stretching? Your answer should include all necessary calculations and a new intensity table like Table-1. **[10]**

Intensity level r_k	**Pixel number n_k**
$r_0 = 0$	$n_0 = 800$
$r_1 = 1$	$n_1 = 1033$
$r_2 = 2$	$n_2 = 850$
$r_3 = 3$	$n_3 = 648$
$r_4 = 4$	$n_4 = 337$
$r_5 = 5$	$n_5 = 245$
$r_6 = 6$	$n_6 = 122$
$r_7 = 7$	$n_7 = 81$

Table-1. Intensity distribution of 3-bit image.

2) An image has a probability density function (PDF) of $p(r) = 2(1-r)$. We want to transform this image so that its PDF becomes $p(z) = 2z$. Assume continuous images and find the transformation (in terms of r and z) that would achieve this goal. **[10]**

3) When we mix blue paint with yellow paint, we get green. But when we project blue light on yellow light, we get brown. How do you explain this contradiction? **[5]**

4) Consider a linear display whose red, green and blue primaries have chromaticity coordinates of $(0.5, 0.4)$, $(0.2, 0.5)$ and $(0.1, 0.1)$ respectively. The maximum intensity (defined by $X+Y+Z$) of white is $1000\ cd/m^2$ respectively. The white point of the display is $(0.33, 0.37)$. What is the XYZ coordinates of the color generated by the RGB input $(0.5, 0.75, 0.2)$ on this device? **[10]**

5) C_1 and C_2 are colors with chromaticity coordinates $(0.33, 0.45)$ and $(0.82, 0.10)$ respectively. In what proportions should these colors be mixed to generate

a color C_3 of chromaticity coordinates $(0.55, 0.28)$? If the brightness of C_3 is 90, what are the brightness of C_1 and C_2? **[10]**

6) Consider four neighboring pixels of I denoted by $a = I(x, y), b = I(x, y+1), c = I(x+1, y)$ and $d = I(x+1, y+1)$. Let us consider a point in the image at location $(x + 0.2, y + 0.8)$. We would like to compute the value of I at P using bilinear interpolation. **[5+3=8]**
   a) Write out the equation for this value in terms of *a, b, c,* and *d.*
   b) What is the degree of this equation?

7) The spectrum of color $C_1 = (X_1, Y_1, Z_1)$ and $C_2 = (X_2, Y_2, Z_2)$ are given by $s_1(\lambda)$ and $s_2(\lambda)$ respectively. Let the color formed by multiplications of the spectrums s_1 and s_2 be s_3, i.e. $s_3(\lambda) = s_1(\lambda) * s_2(\lambda)$. Is it true that the XYZ coordinate corresponding to s_3, denoted by C_3, is (X_1X_2, Y_1Y_2, Z_1Z_2)? Justify your answer with calculations. **[5]**

8) Consider two spectra, $s_1(\lambda)$ and $s_2(\lambda)$, that are metamers for viewer *A*. However, these two spectra are not a metamer for another viewer *B*. Why does this situation happen? **[3]**

9) Consider the color $C = (0.2, 0.4)$ in the chromaticity chart. Find its hue and saturation. Provide the chromaticity coordinate of a color *B* which when mixed with *C* will produce white. Find the hue of *B*. **[2+3+3+2=10]**

10) Answer the following questions about 2D geometric transformations: **[2+2+2+3=9]**
   a. What transformation does the following matrix represent?

$$\begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix}$$

   b. Provide a matrix transformation which is the inverse of the transformation in part-(a).
   c. What is the 2D transformation matrix that will reduce an image to half its size?
   d. Provide a single 2D transformation matrix that will reduce an image to half its size, then rotates it by 30 degrees anticlockwise.