Homework 1

‘‘Computer vision’’

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Theory questions:

1. Luminance refers to the absolute amount of light emitted by an object per unit area, whereas luminosity refers to the perceived brightness of that object by a human observer. In fact luminance is the intensity of light reflected from a surface. Think of a lamp shining in a dark room — luminance would describe the amount of the light passing through the lightbulb.
   Actually Luminance is a major measurement for anything that projects light, whether that be as a display or as a light source. It’s an objective, numerical measurement is lumens over a certain area. This is a necessary number for understanding light sources and how much light falls on an object.

   brightness is more properly described as the measured intensity of all the pixels comprising an ensemble that constitutes the digital image after it has been captured, digitized, and displayed. Since brightness is a relative term, brightness can be defined as the amount of energy output by a source of light relative to the source we are comparing it to. In some cases we can easily say that the image is bright, and in some cases, it's not easy to perceive.

   Difference between Luminance and brightness: Luminance is a quantifiable, measurable characteristic. Meanwhile, brightness cannot be objectively measured — it can only be perceived. We recognize that a light source is bright or dim, making brightness the visual sensation by which we become aware of differences in luminance. So in fact luminance is the light that the light source creates, and brightness is how dim or bright that light looks to individuals. Each is important to keep in mind and will impact how you should interact with and adjust lighting in your area. This matters in image processing because two objects with the same luminance can have different brightness for two different person.

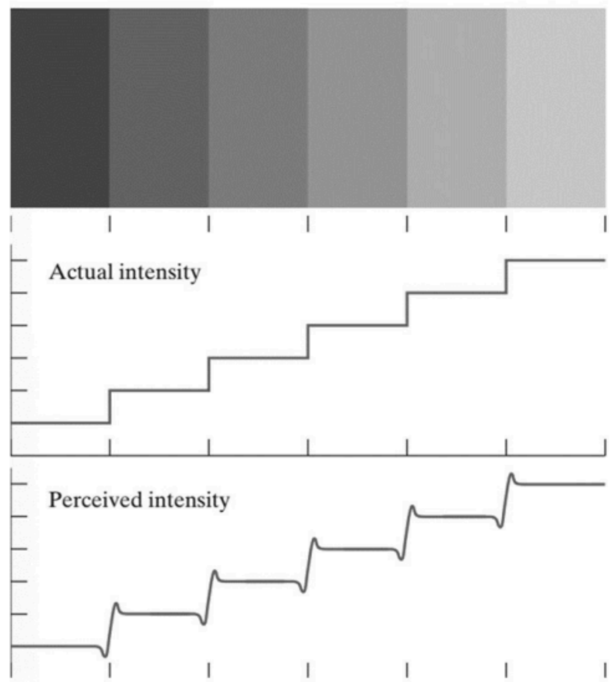


Image description: Above image is a visual representation of how human perception of color intensity is different from the actual intensity of a color. First image is the image of sic color plus their intensities. As we can see in the second plot each color has a specific luminance value which decreases gradually from right to left in the image.In the third plot we see how our perception of brightness might differ from the actual luminance of the colors. Despite the even distribution of two different colors in two different regions, our perception emphasizes the transition between these colors. It shows that what the human eye perceives is a sharper transition between these colors and the boundary between the two colors appears to have higher intensity compared to its surroundings. Plus we see as we mentioned before brightness is subjective so in the same color the perceived intensity which can be described as brightness is not the same all the time and this proves our statment.

2. A) First we convert the RGB values to percentage values:

   $R' = 251 / 255 \approx 0.9843$
   $G' = 151 / 255 \approx 0.5922$
   $B' = 51 / 255 \approx 0.2000$

   Then we calculate the CMYK values:

   $C = 1 - R' = 1 - 0.9843 \approx 0.0157$
   $M = 1 - G' = 1 - 0.5922 \approx 0.4078$
   $Y = 1 - B' = 1 - 0.2000 = 0.8000$

   $K = \min(C, M, Y) = \min(0.0157, 0.4078, 0.8000) = 0.0157$

   B) we can use this formula to calculate YIQ:

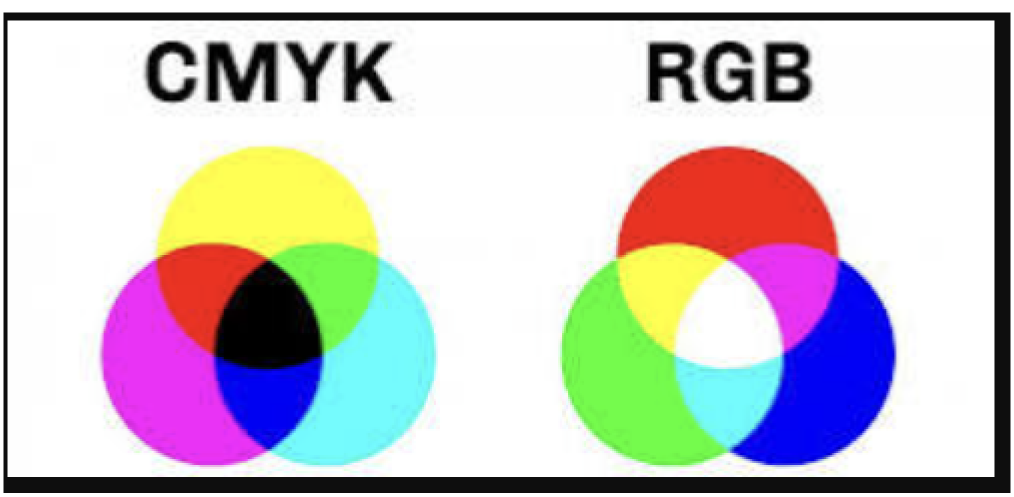
   $Y = 0.299R' + 0.587G' + 0.114B' \approx 0.8357$
   $I = 0.596R' - 0.274G' - 0.322B' \approx 0.2693$
   $Q = 0.211R' - 0.523G' + 0.312B' \approx 0.3255$

C) here is how we calculate values using conversion matrix:

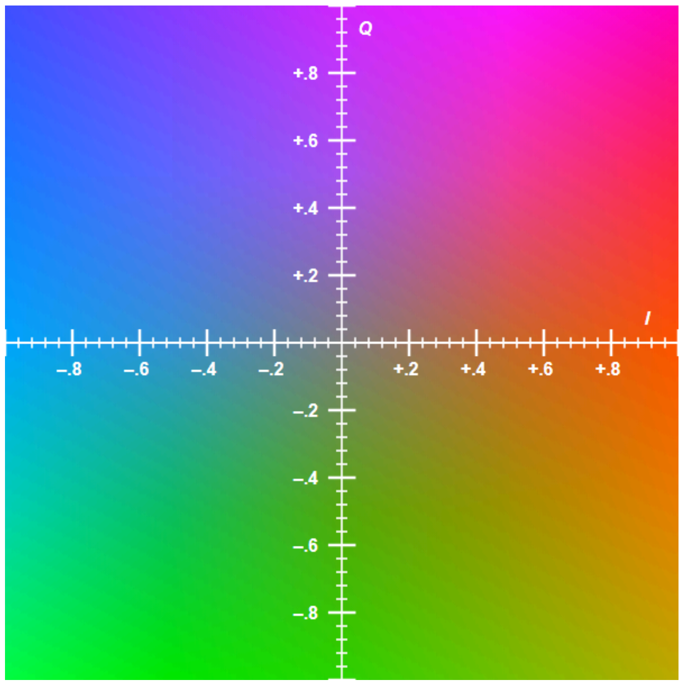
$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Y = 16 + (65.481 * R' + 128.553 * G' + 24.966 * B') ≈ 160.84
Cb = 128 + (-37.797 * R' - 74.203 * G' + 112.0 * B') ≈ 69.27
Cr = 128 + (112.0 * R' - 93.786 * G' - 18.214 * B') ≈ 178.02

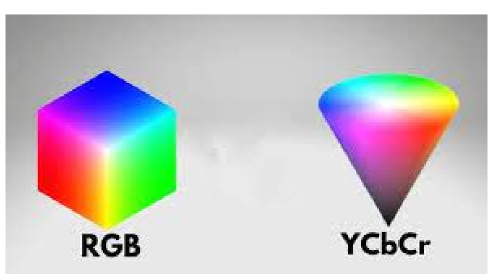
D) CMYK: CMYK stands for cyan (C), magenta (M), yellow (Y), and black (K for “key”), and is the color mode used by commercial printing equipment to create full-color graphics and images. The printing process involves combining varying amounts of the different color inks to produce a full spectrum of color. The “K” representing black, for “key”, refers to the printing plates being keyed, or aligned, to the black printing plate. CMYK color is also called process color, or four-color process.



YIQ: YIQ is used in Television broadcasting. Y stands for luminance part and IQ stands for chrominance part. In the black and white television, only the luminance part (Y) was broadcast. The y value is similar to the grayscale part. The color information is represented by the IQ part. YIQ model separated chrominance from luminance. Luminance information is contained on the Y-channel, whereas color information is carried on I and Q channels (in-phase and in-quadrature) , in-short YIQ(Luminance, In-phase, Quadrature). In addition to providing a signal that could be displayed directly on black-and-white TVs, the system provided easy coding and decoding of RGB signals which was not directly possible.



YCbCr: The YCbCr color space is widely used for digital video. In this format, luminance information is stored as a single component (*Y*) and chrominance information is stored as two color-difference components (*Cb* and *Cr*). Cb and Cr represent the difference between a reference value and the blue or red component, respectively.



Attribute	Description
Y	Luminance or brightness of the image. Colors increase in brightness as Y increases.
Cb	Chrominance value that indicates the difference between the blue component and a reference value.
Cr	Chrominance value that indicates the difference between the red component and a reference value.

Usability:

CMYK is used in color printing because it shows the colors achievable through the color mixing process used in printing. CMYK has a narrower color gamut compared to RGB. So it cannot represent all the colors that are visible to the human eye. So CMYK is not typically used for digital displays like monitors or screens. Because digital devices use additive color models like RGB or YCbCr.
YIQ is historically used in analog television systems. It separates luminance (Y) from chrominance (I and Q). This allows efficient transmission of color information and maintains compatibility with black-and-white TVs. With the transition to digital television and video format, YIQ is less usable in modern digital systems. However, it may still be available on older systems or certain specialized applications.
YCbCr is widely used in digital imaging and video compression formats like JPEG, MPEG and etc. it is also used in digital cameras, video cameras, and displays. Because of its efficiency in representing and compressing color information. YCbCr can represent a wide range of colors. it is compatible with various digital imaging and video processing techniques.

3. A) This is how we do Histogram Equalization:

First we calculate s:

$$p_r(r) = 2 - 2r \quad \rightarrow \quad s = \int_0^r p_r(w)dw = r^2 - 2r$$

Then we calculate G(z):

$$p_z(z) = 2z \quad \rightarrow \quad G(z) = \int_0^z p_z(t)dt = z^2$$

So the final function would be:

$$z = G^{-1}(s)$$

$$G^{-1}(z) = z^{\frac{1}{2}}$$

$$T(r) = z = (r^2 - 2r)^{\frac{1}{2}}$$

4. A) First we make this table:

intensity value	count	Scaled
1	8	0.14
2	8	0.28
3	2	0.42
5	7	0.71

Then we calculate new values:

PMF	CDF	s	Equalized
8.25	8.25	2.24	2
8.25	16.25	4.48	4
2.27	18.25	5.04	5
7.25	1	7	7

So the final image is:

2 4 2 2 2

4 7 5 7 4

4 7 7 7 4

4 7 5 7 4

2 2 2 4 2

B) We have 4 values for brightness so we just display the bit values:

1: 0 0 0 0 0 0 0 1
2: 0 0 0 0 0 0 1 0
3: 0 0 0 0 0 0 1 1
5: 0 0 0 0 0 1 0 1

And bit-planes are these one and others would be 0:

Bit 0 :
1 0 1 1 1
0 1 1 1 0
0 1 1 1 0
0 1 1 1 0
1 1 1 0 1

Bit 1 :
0 1 0 0 0
1 0 1 0 1
1 0 0 0 1
1 0 1 0 1
0 0 0 1 0

Bit 2 :
0 0 0 0 0
0 1 0 1 0
0 1 1 1 0
0 1 0 1 0

0 0 0 0 0

C) We just linearly stretch the range of pixel values to cover the entire intensity range:

First we find min_val and max_val and scale value:
min_val = 1
max_val = 5
scale = (7 - 0) / (5 - 1) = 7 / 4 = 1.75

Then we apply the scaling factor to each pixel value:
new_val = (pixel_value - min_val) * scale

For pixel value 1:
new_val = (1 - 1) * 1.75 = 0

For pixel value 2:
new_val = (2 - 1) * 1.75 = 1.75 ≈ 2

For pixel value 3:
new_val = (3 - 1) * 1.75 =3.5 ≈ 4

For pixel value 5:
new_val = (5 - 1) * 1.75 = 7

So the final image is:

0 2 0 0 0
2 7 4 7 2
2 7 7 7 2
2 7 4 7 2

0 0 0 2 0

Sources :

[Brightness and Contrast (tutorialspoint.com)]

[Understanding Digital Camera Histograms: Luminosity and Color (cambridgeincolour.com)]

[The Difference Between Luminance and Brightness (gamma-sci.com)]

[What is CMYK Color? | Plum Grove (plumgroveinc.com)]

[YIQ Color Model in Computer Graphics - GeeksforGeeks]

[Understanding Color Spaces and Color Space Conversion - MATLAB & Simulink (mathworks.com)]