

ECE637 Digital Image Processing I
Laboratory work 6:
Introduction to Colorimetry

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2 Plotting Color Matching Functions and Illuminants

2.1 The plot of the $x_0(\lambda)$ $y_0(\lambda)$ and $z_0(\lambda)$ color matching functions

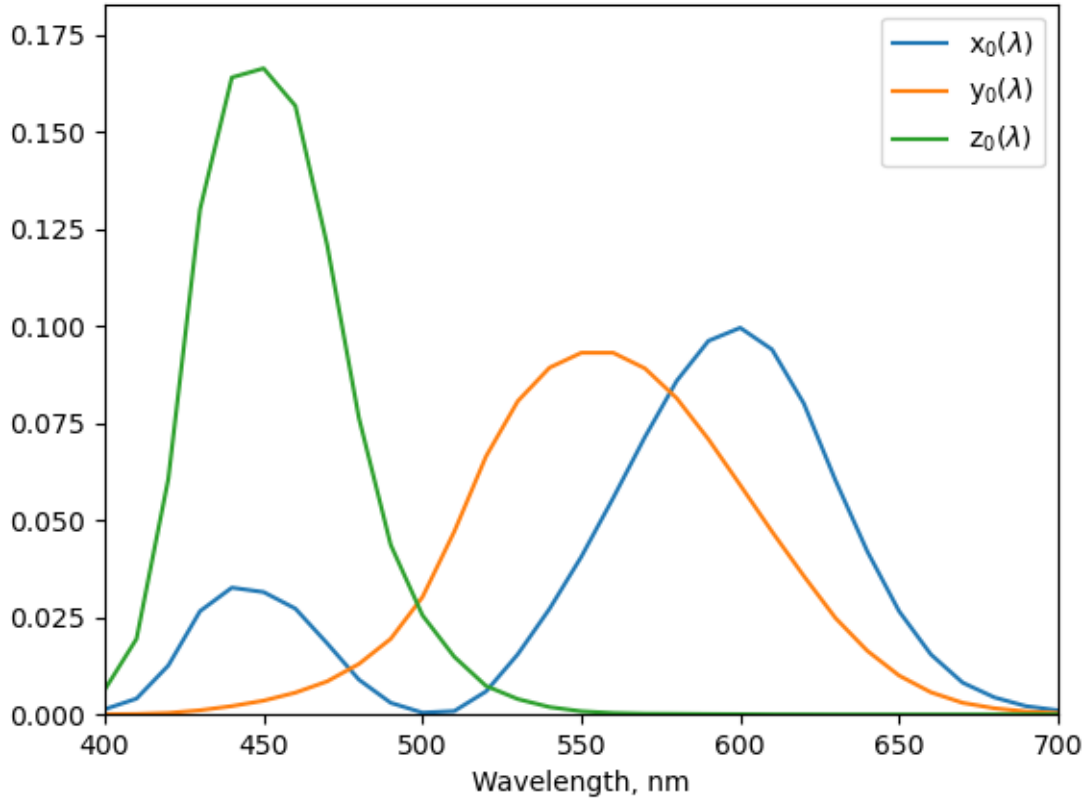


Figure 1: The plot of $x_0(\lambda)$, $y_0(\lambda)$, and $z_0(\lambda)$ color matching functions

2.2 The plot of the $l_0(\lambda)$ $m_0(\lambda)$ and $s_0(\lambda)$ color matching functions

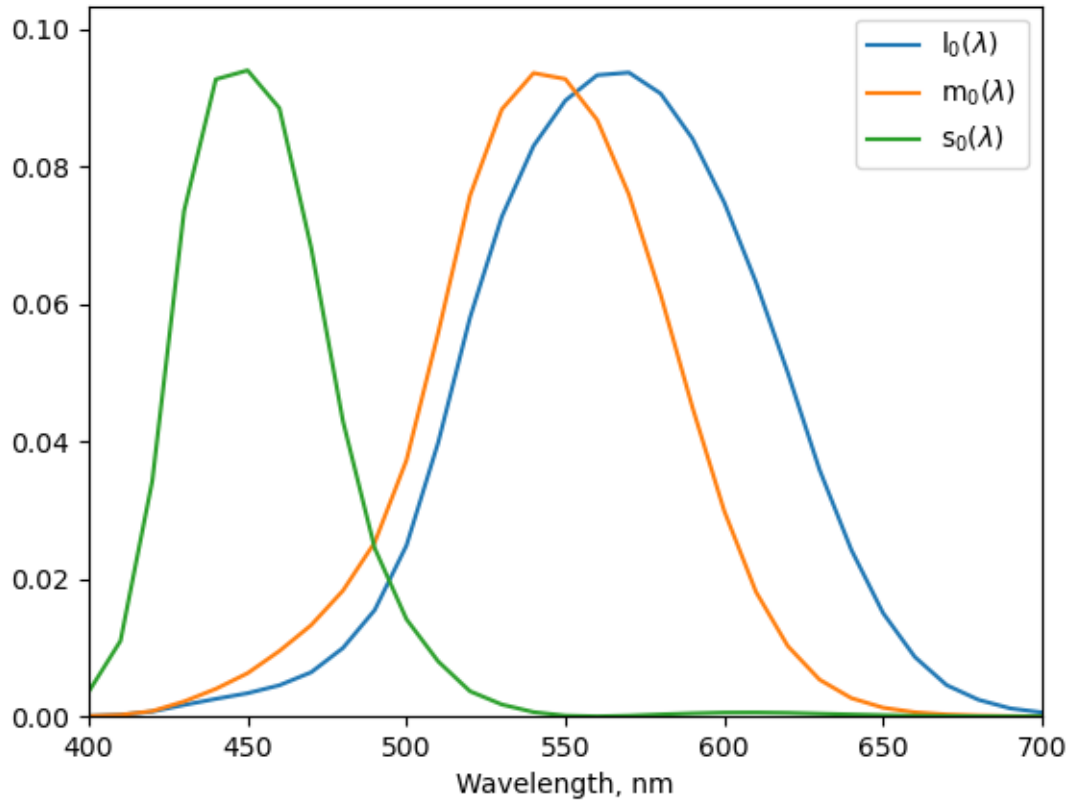


Figure 2: The plot of the $l_0(\lambda)$, $m_0(\lambda)$, and $s_0(\lambda)$ color matching functions corresponding to the long, medium, and short cones

2.3 The plot of the D_{65} and fluorescent illuminants

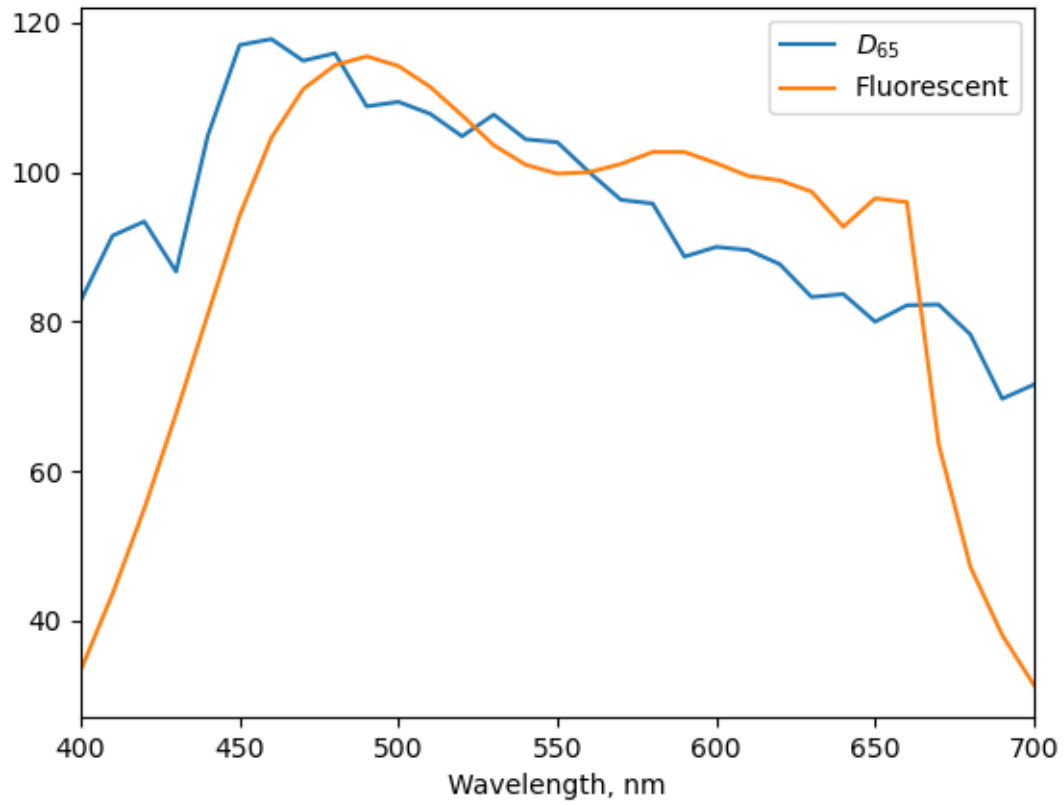


Figure 3: The spectrum of the D_{65} and fluorescent illuminants vs. wavelength

3 Chromaticity Diagrams

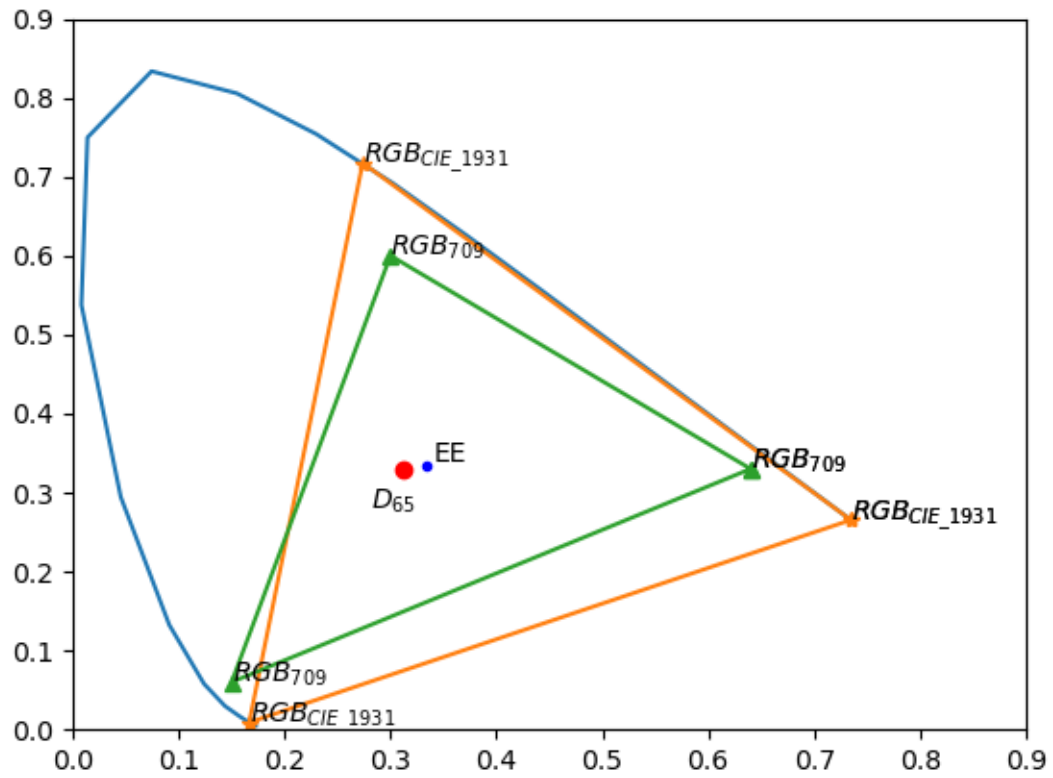


Figure 4: The chromaticity diagram for CIE 1931 and Rec. 709 RGB primaries

4 Rendering an Image from Illuminant, Reflectance, and Color Matching Functions

4.1 The matrix M_{709_D65}

We know that

$$M = \begin{bmatrix} x_r & x_g & x_b \\ y_r & y_g & y_b \\ z_r & z_g & z_b \end{bmatrix} \begin{bmatrix} \kappa_r & 0 & 0 \\ 0 & \kappa_g & 0 \\ 0 & 0 & \kappa_b \end{bmatrix} \quad (1)$$

We are given the standard Rec. 709 RGB primaries, so we have

$$\begin{bmatrix} x_r & x_g & x_b \\ y_r & y_g & y_b \\ z_r & z_g & z_b \end{bmatrix} = \begin{bmatrix} 0.640 & 0.300 & 0.150 \\ 0.330 & 0.600 & 0.060 \\ 0.030 & 0.100 & 0.790 \end{bmatrix} \quad (2)$$

To find the scaling constants κ_r , κ_g , and κ_b , one should use the following relation

$$\begin{bmatrix} \kappa_r \\ \kappa_g \\ \kappa_b \end{bmatrix} = \begin{bmatrix} x_r & x_g & x_b \\ y_r & y_g & y_b \\ z_r & z_g & z_b \end{bmatrix}^{-1} \begin{bmatrix} x_{wp}/y_{wp} \\ 1 \\ z_{wp}/y_{wp} \end{bmatrix} \quad (3)$$

So, we need to find the inverse of the matrix (2) and use the data about the white point.

We are given a D_{65} white point, that is

$$\begin{bmatrix} x_{wp} \\ y_{wp} \\ z_{wp} \end{bmatrix}_{D_{65}} = \begin{bmatrix} 0.3127 \\ 0.3290 \\ 0.3583 \end{bmatrix}$$

Or, equivalently

$$\begin{bmatrix} x_{wp}/y_{wp} \\ 1 \\ z_{wp}/y_{wp} \end{bmatrix}_{D_{65}} = \begin{bmatrix} 0.3127/0.3290 \\ 1 \\ 0.3583/0.3290 \end{bmatrix} \quad (4)$$

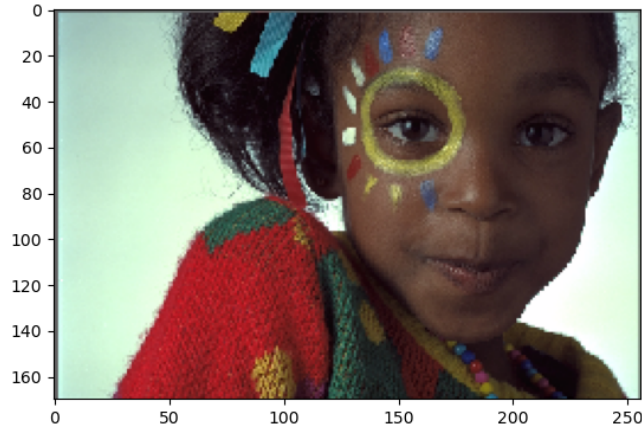
After performing the operations described above (finding the inverse of (2) and plugging (4) in (3)), we calculate the constants κ_r , κ_g , and κ_b

$$\begin{bmatrix} \kappa_r \\ \kappa_g \\ \kappa_b \end{bmatrix} = \begin{bmatrix} 0.6444 \\ 1.1919 \\ 1.1203 \end{bmatrix} \quad (5)$$

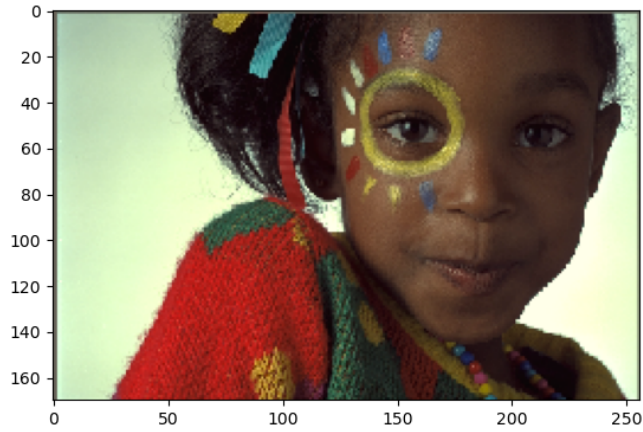
Finally, we have all the necessary information to compute M using (1)

$$M = \begin{bmatrix} 0.4124 & 0.3576 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9505 \end{bmatrix} \quad (6)$$

4.2 The two images obtained from D_{65} and fluorescent light sources

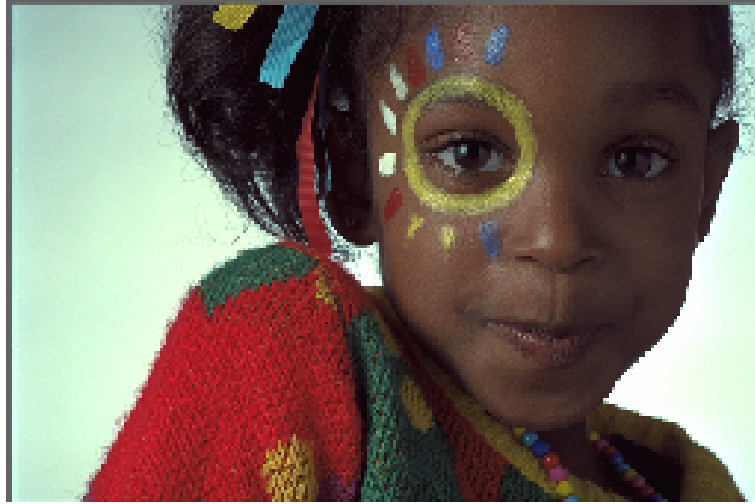


(a) D65 light source



(b) Fluorescent light source

Figure 5: The images obtained from D_{65} and fluorescent light sources (exported)



(a) D65 light source



(b) Fluorescent light source

Figure 6: The images obtained from D_{65} and fluorescent light sources (saved using the *Image* from *PIL*)

4.3 A qualitative description of the differences between the two images

The image obtained from the fluorescent light source looks "warmer" and brighter than the one obtained from the D_{65} light source.

5 Color Chromaticity Diagram

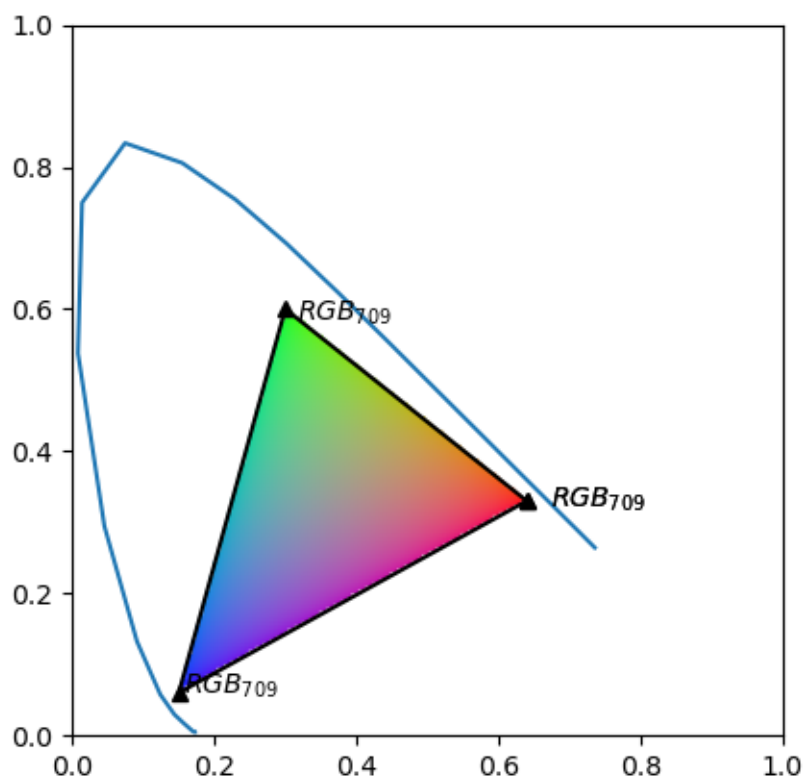


Figure 7: The color diagram