Due Friday, 17 September 2021 at 11:59p EDT

ECE 638 Homework No. 2 Fall 2021

Be sure to turn in all your Matlab or Python code for the problems below.

1. Consider a finite dimensional model for a linear, bichromatic (2-channel) vision system. Assume that we sample at $N = 3$ wavelengths. Suppose that the sensor response matrix is given by

$$\mathbf{S} = \begin{bmatrix} 0.25 & 0.25 \\ 1 & 0.5 \\ 0.25 & 1 \end{bmatrix}$$

   a. Find the response of this sensor to the stimulus $\vec{n} = \begin{bmatrix} 2 & 2 & 1 \end{bmatrix}^T$.

   b. Find the fundamental component $\vec{n}^*$ for this stimulus.

   c. Find the black-space component $\vec{n}^c$ for the stimulus.

   d. Find a metamer $\vec{n}'$ to $\vec{n}$ such that $\vec{n}' \neq \vec{n}$.

   e. Find the projection operator $\mathbf{R}$ for this sensor.

2.
   a. Using the cone responses posted at the course website, use Matlab to find the projection operator $\mathbf{R}$ for the human visual subspace. Plot it as a mesh-plot.
   b. Use your projection operator to find the fundamental component and black-space components of the D65 illuminant, which is also posted in the data section at the course website. Plot these components as a function of wavelength.

3. Shown below is a plot containing the black-body curve as a function of CIE xy chromaticity coordinates. The straight lines indicate xy values that correspond to the same correlated color temperature, as indicated by the intersection with the black-body curve. These lines are based on psychophysical measurements, and allow us to assign a correlated color temperature to points that are located far from the black-body curve. The actual color temperature is indicated by the numbers at the lower ends of these lines.

   a. From the course website, download the spectral power distribution for the D65 illuminant, and use the CIE $(\bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda))$ color matching functions to compute the corresponding CIE xy chromaticity coordinates for this illuminant. From the figure below, estimate the correlated color temperature for this illuminant.

   b. Repeat part a.) above for Illuminant A, for which the spectral power distribution can also be downloaded from the course website.

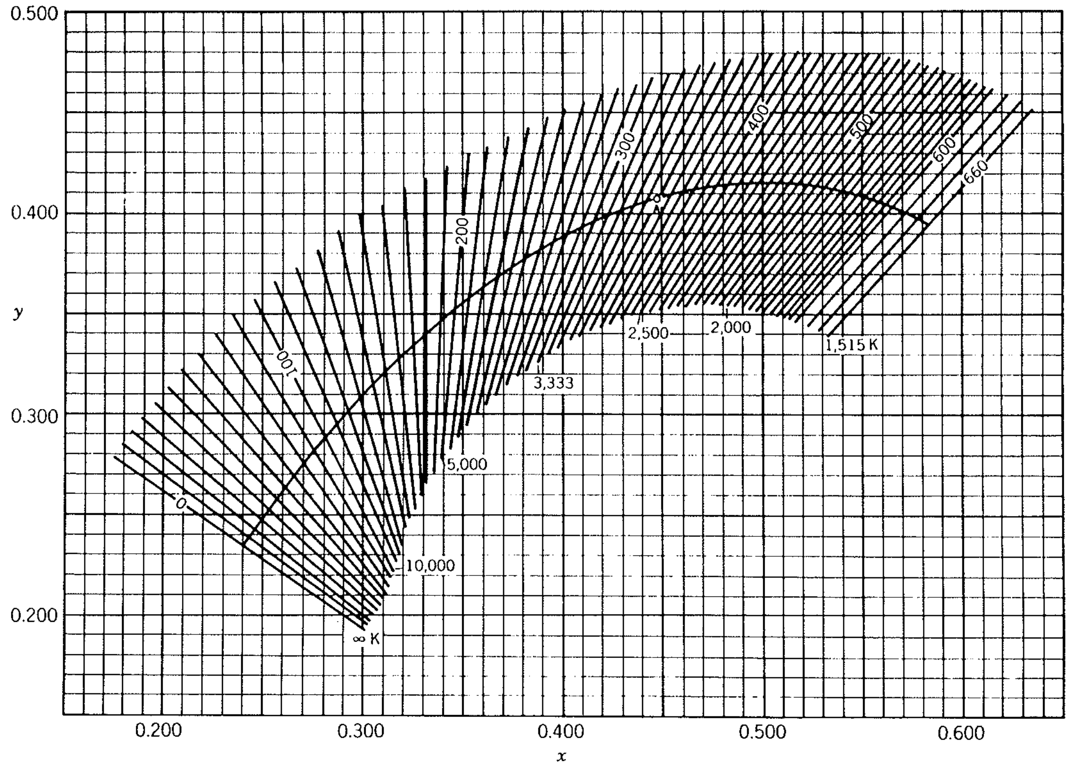

Fig. 1(3.11). CIE 1931 (x, y)-chromaticity diagram showing isotemperature lines as computed by Kelly (1963).

4. The CIE 1976 $L^*a^*b^*$ uniform color space is commonly described only in terms of the forward equations that map CIE XYZ to CIE $L^*a^*b^*$. Derive the inverse mapping that will take us from CIE $L^*a^*b^*$ back to CIE XYZ.

5. This is a continuation of Problem 4 on HW No. 1. For the three color patches – Red, Green, and Blue, compute the CIE L*a*b* coordinates using the data from the table below. Then, generate the following three plots, with the color coordinates of all three color patches shown on the same axes.

a. L* vs. a*

b. L* vs. b*

c. b* vs. a*

Comment on the location of these points in terms of the shapes of the three power spectral distributions, and the visual appearance of the three patches in terms of hue, saturation, and lightness.

Color	x	y	Y
Red	0.5359	0.321	32.56

Green	0.3082	0.496	64.78
Blue	0.1985	0.1507	18.34