EE 637 Study Solutions - Assignment 9

Topics: Color spaces, and perceptual uniformity

Spring 2006 Exam 2: Problem 1 (Lab space)

The approximate *Lab* color space transform is given by

$$\begin{aligned} L &= 100(Y/Y_0)^{1/3} \\ a &= 500\left[(X/X_0)^{1/3} - (Y/Y_0)^{1/3}\right] \\ b &= 200\left[(Y/Y_0)^{1/3} - (Z/Z_0)^{1/3}\right] \end{aligned}$$

a) What are the values of X_0, Y_0, and Z_0 supposed to represent? Typically, what values might be used for these constants? (You don't have to give the specific decimal quantities, just specify a typical choice.)

Solution:

(X_0, Y_0, Z_0) is the white point. A typical value would be the chromaticity of D65 scaled so that it corresponds to the maximum value of (X, Y, Z).

b) Why are the quantities (X/X_0), (Y/Y_0), and (Z/Z_0) raised to the power 1/3?

Solution:

This accounts for the perceptual sensitivity to contrast and is similar to gamma correction.

c) Why are the quantities $(X/X_0)^{1/3}$ and $(Y/Y_0)^{1/3}$ subtracted for the calculation of a, and the quantities $(Y/Y_0)^{1/3}$ and $(Z/Z_0)^{1/3}$ subtracted for the calculation of b?

Solution:

This is an approximate opponent color channel transformation.

d) Specify an application for which the *Lab* color space is well suited. Why?

Solution:

Paint matching, because these patches have low spatial frequency.

e) Specify an application for which the *Lab* color space is poorly suited. Why?

Solution:

Measuring fidelity of compressed images because the errors have high spatial frequency.

Spring 2006 Final: Problem 2 (color transformations)

Consider the color space given by

$$\begin{bmatrix} r \\ g \\ b \end{bmatrix} = M \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

where X, Y, and Z denote the standard CIE color space, and $[r, g, b]$ are the tristimulus values corresponding to physically displayed red (R), green (G), and blue (B) color primaries.

a) Are the entries in the matrix M positive (i.e. ≥ 0), negative (i.e. < 0) or a combination of positive and negative. Justify your answer.

Solution:

Both positive and negative because X, Y, Z correspond to imaginary primaries which are the columns of M.

b) Are the entries in the matrix M^{-1} positive (i.e. ≥ 0), negative (i.e. < 0) or a combination of positive and negative. Justify your answer.

Solution:

The entries in M^{-1} are all positive because r, g, b primaries can always be specified with positive XYZ values.

c) What does the second column of M^{-1} represent?

Solution:

The green primary in X, Y, Z coordinates.

d) What does it tell you if the rows of M^{-1} sum to 1?

Solution:

The white point is equal energy white.