APPLICATIONS NOTE
The world's true measure of color
HunterLab
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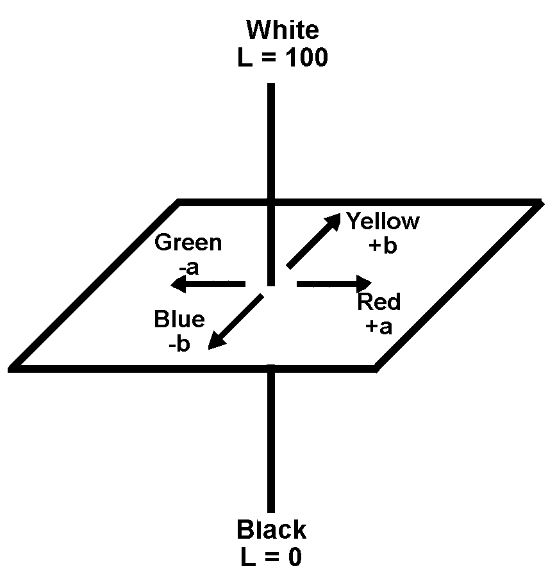
Hunter Lab Color Scale

Background

The Hunter Lab color scale evolved during the 1950s and 1960s. At that time, many of the scientists involved with color measurement were working on uniform color scales. The XYZ system was being used, but it did not give a good indication of sample color based solely on the numbers. The uniform color scales being investigated gave better indications of the color of a sample based solely on the numbers. There were several permutations of the Hunter Lab color scale before the current formulas were released in 1966.

The Hunter Lab color scale is more visually uniform than the XYZ color scale. In a uniform color scale, the differences between points plotted in the color space correspond to visual differences between the colors plotted. The Hunter Lab color space is organized in a cube form. The L axis runs from top to bottom. The maximum for L is 100, which would be a perfect reflecting diffuser. The minimum for L would be zero, which would be black. The a and b axes have no specific numerical limits. Positive a is red. Negative a is green. Positive b is yellow. Negative b is blue. Below is a diagram of the Hunter Lab color space.



There are delta values (ΔL, Δa, and Δb) associated with this color scale. These values indicate how much a standard and sample differ from one another in L, a, and b. The ΔL, Δa, and Δb values are often used for quality control or formula adjustment. Tolerances may be set for the delta values. Delta values that are out of tolerance indicate that there is too much difference between the standard and the sample. The type of correction needed may be determined by which delta value is out of tolerance. For example, if Δa is out of tolerance, the redness/greenness needs to be adjusted. Whether the sample is redder or greener than the standard is indicated by the sign of the delta value. For example, if Δa is positive, the sample is redder than the standard.

The total color difference, ΔE, may also be calculated. ΔE is a single value that takes into account the differences between the L, a, and b of the sample and standard. It does not indicate which parameter is out of tolerance if ΔE is out of tolerance. It may also be misleading in some cases where ΔL, Δa, or Δb is out of tolerance, but ΔE is still within the tolerance.

The Hunter Lab color scale may be used on any object whose color may be measured. It is not used as frequently today as it was in the past because the CIE L*a*b* scale, which was released in 1976, has gained popularity.

Conditions for Measurement

Instrumental: Any HunterLab color measurement instrument

Illuminant: Any

Standard Observer Function: Either 2 or 10 degree

Transmission and/or Reflectance: Either

Formulas

$$L = 100\sqrt{\frac{Y}{Y_n}}$$

$$a = K_a\left(\frac{X/X_n - Y/Y_n}{\sqrt{Y/Y_n}}\right)$$

$$b = K_b\left(\frac{Y/Y_n - Z/Z_n}{\sqrt{Y/Y_n}}\right)$$

where

X, Y, and Z are the CIE tristimulus values.

X_n, Y_n, and Z_n are the tristimulus values for the illuminant.

Y_n is 100.00.

X_n and Z_n are listed in the tables below.

K_a and K_b are chromaticity coefficients for the illuminant and are listed in the tables below.

CIE 2 Degree Standard Observer

Illuminant	X_n	Z_n	K_a	K_b
A	109.83	35.55	185.20	38.40
C	98.04	118.11	175.00	70.00
D_{65}	95.02	108.82	172.30	67.20
F2	98.09	67.53	175.00	52.90
TL 4	101.40	65.90	178.00	52.30
UL 3000	107.99	33.91	183.70	37.50
D_{50}	96.38	82.45	173.51	58.48
D_{60}	95.23	100.86	172.47	64.72
D_{75}	94.96	122.53	172.22	71.30

CIE 10 Degree Standard Observer

Illuminant	X_n	Z_n	K_a	K_b
A	111.16	35.19	186.30	38.20
C	97.30	116.14	174.30	69.40
D_{65}	94.83	107.38	172.10	66.70
F2	102.13	69.37	178.60	53.60
TL 4	103.82	66.90	180.10	52.70
UL 3000	111.12	35.21	186.30	38.20
D_{50}	96.72	81.45	173.82	58.13
D_{60}	95.21	99.60	172.45	64.28
D_{75}	94.45	120.70	171.76	70.76

$\Delta L = L_{sample} - L_{standard}$ + ΔL means sample is lighter than standard
- ΔL means sample is darker than standard

$\Delta a = a_{sample} - a_{standard}$ + Δa means sample is redder than standard
- Δa means sample is greener than standard

$\Delta b = b_{sample} - b_{standard}$ + Δb means sample is yellower than standard
- Δb means sample is bluer than standard.

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}.$$

Typical Applications

This color scale may be used for measurement of the color of any object whose color can be measured.

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