Delta E (CIE 2000)

The color difference, or ΔE, between a sample color $L_2a_2b_2$ and a reference color $L_1a_1b_1$ is:

$$\Delta E = \sqrt{\left(\frac{\Delta L'}{K_L S_L}\right)^2 + \left(\frac{\Delta C'}{K_C S_C}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{K_C S_C}\right)\left(\frac{\Delta H'}{K_H S_H}\right)}$$

where

$$\overline{L}' = (L_1 + L_2)/2$$

$$C_1 = \sqrt{a_1^{\,2} + b_1^{\,2}}$$

$$C_2 = \sqrt{a_2^{\,2} + b_2^{\,2}}$$

$$\overline{C} = (C_1 + C_2)/2$$

$$G = \left(1 - \sqrt{\frac{\overline{C}^{\,7}}{\overline{C}^{\,7} + 25^7}}\right)\Big/2$$

$$a_1' = a_1(1+G)$$

$$a_2' = a_2(1+G)$$

$$C_1' = \sqrt{a_1'^{\,2} + b_1^{\,2}}$$

$$C_2' = \sqrt{a_2'^{\,2} + b_2^{\,2}}$$

$$\overline{C}' = (C_1' + C_2')/2$$

$$h_1' = \begin{cases} \tan^{-1}(b_1/a_1') & \tan^{-1}(b_1/a_1') \geq 0 \\ \tan^{-1}(b_1/a_1') + 360^\circ & \tan^{-1}(b_1/a_1') < 0 \end{cases}$$

$$h_2' = \begin{cases} \tan^{-1}(b_2/a_2') & \tan^{-1}(b_2/a_2') \geq 0 \\ \tan^{-1}(b_2/a_2') + 360^\circ & \tan^{-1}(b_2/a_2') < 0 \end{cases}$$

$$\overline{H}' = \begin{cases} (h_1' + h_2' + 360^\circ)/2 & |h_1' - h_2'| > 180^\circ \\ (h_1' + h_2')/2 & |h_1' - h_2'| \leq 180^\circ \end{cases}$$

$$T = 1 - 0.17\cos(\overline{H}' - 30^\circ) + 0.24\cos(2\overline{H}') + 0.32\cos(3\overline{H}' + 6^\circ) - 0.20\cos(4\overline{H}' - 63^\circ)$$

$$\Delta h' = \begin{cases} h_2' - h_1' & |h_2' - h_1'| \leq 180^\circ \\ h_2' - h_1' + 360^\circ & |h_2' - h_1'| > 180^\circ; h_2' \leq h_1' \\ h_2' - h_1' - 360^\circ & |h_2' - h_1'| > 180^\circ; h_2' > h_1' \end{cases}$$

$$\Delta L' = L_2 - L_1$$

$$\Delta C' = C_2' - C_1'$$

$$\Delta H' = 2\sqrt{C_1' C_2'}\sin(\Delta h'/2)$$

$$S_L = 1 + \frac{0.015(\overline{L}' - 50)^2}{\sqrt{20 + (\overline{L}' - 50)^2}}$$

$$S_C = 1 + 0.045\overline{C}'$$

Implementation Notes:

1. The angles supplied to the *sin* and *cos* functions are shown in degrees. Most math libraries expect radians, so don't forget to convert.
2. The inverse tangent is also expressed in degrees. In most math libraries, the inverse tangent returns radians, so don't forget to convert.
3. In computing hue angles, be careful with the inverse tangent since *a* could be zero. Instead, use special math functions to do this. In both the Standard C library and Java, this function is called **atan2**. In Microsoft Excel, it is called **ATAN2**. These special functions will compute the proper inverse tangents without needing to worry about "divide by zero" conditions.

Top of Page
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