




Implementation of CIEDE2000

ISO TC130, ICC and CIE D1
Workshop

July, 2013



Which version?

- *CIE 014-6/E:2013 Colorimetry - Part 6: CIEDE2000 Colour-Difference Formula*
- *Including 3-terms and 4-terms equations*

Research challenges

- SCOPE, References
- Definitions, symbols and abbreviations
- Reference conditions
- Calculation method
- Parametric factors
- Appendix: Three-component micro-spaces.

Modified CIELAB coordinates

$$L' = L^*$$

$$a' = (1 + G)a^*$$

$$b' = b^*$$

$$C' = \sqrt{a'^2 + b'^2}$$

$$h' = \begin{cases} \arctan\left(\frac{b'}{a'}\right), & \text{if } C' \neq 0 \\ 0, & \text{if } C' = 0 \end{cases}$$

where

$$G = 0.5 \left(1 - \sqrt{\frac{(C_{ab}^*)^7}{(C_{ab}^*)^7 + 25^7}} \right)$$

Differences between two samples

$$\Delta L' = L'_1 - L'_0$$

$$\Delta C' = C'_1 - C'_0$$

$$\Delta H' = 2\sqrt{C'_0 C'_1} \cos(\Delta h' / 2)$$

where

$$\Delta h' = \begin{cases} 0 & \text{if } C'_0 C'_1 = 0 \\ h'_1 - h'_0 & \text{if } C'_0 C'_1 \neq 0 \text{ and } |h'_1 - h'_0| \leq 180 \\ h'_1 - h'_0 - 360 & \text{if } C'_0 C'_1 \neq 0 \text{ and } h'_1 - h'_0 > 180 \\ h'_1 - h'_0 + 360 & \text{if } C'_0 C'_1 \neq 0 \text{ and } h'_1 - h'_0 < -180 \end{cases}$$

The CIEDE2000 colour difference

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'_{ab}}{k_C S_C}\right)^2 + \left(\frac{\Delta H'_{ab}}{k_H S_H}\right)^2 + R_T \left(\frac{\Delta C'_{ab}}{k_C S_C}\right) \left(\frac{\Delta H'_{ab}}{k_H S_H}\right)}$$

where

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

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

$$S_H = 1 + 0.015\overline{C'_{ab}} T$$

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

$$R_T = -\sin(2\Delta\theta)R_C$$

$$\Delta\theta = 30 \exp\left\{-\left[\frac{(\overline{h'_{ab}} - 275^\circ)/25}{25}\right]^2\right\}$$

$$R_C = 2 \sqrt{\frac{\overline{C'_{ab}}^7}{\overline{C'_{ab}}^7 + 25^7}}$$

The mean hue angle

$$\bar{h}' = \begin{cases} (h'_1 + h'_0) / 2 & \text{if } |h'_1 - h'_0| \leq 180 \text{ and } C'_0 C'_1 \neq 0 \\ (h'_1 + h'_0 + 360) / 2 & \text{if } |h'_1 - h'_0| > 180 \text{ and } h'_1 + h'_0 < 360 \text{ and } C'_0 C'_1 \neq 0 \\ (h'_1 + h'_0 - 360) / 2 & \text{if } |h'_1 - h'_0| > 180 \text{ and } h'_1 + h'_0 \geq 360 \text{ and } C'_0 C'_1 \neq 0 \\ h'_1 + h'_0 & \text{if } C'_0 C'_1 = 0 \end{cases}$$

THREE-COMPONENT MICRO-SPACES

$$\Delta E_{00} = \sqrt{(\Delta L_{00})^2 + (\Delta C_{00})^2 + (\Delta H_{00})^2}$$

$$\tan(2\theta) = R_T \frac{(k_C S_C)(k_H S_H)}{(k_H S_H)^2 - (k_C S_C)^2}$$

$$\Delta C'' = \Delta C' \cos(\theta) + \Delta H' \sin(\theta)$$

$$\Delta H'' = \Delta H' \cos(\theta) - \Delta C' \sin(\theta)$$

$$S_C'' = (k_C S_C) \sqrt{\frac{2(k_H S_H)}{2(k_H S_H) + R_T (k_C S_C) \tan(\theta)}}$$

$$S_H'' = (k_H S_H) \sqrt{\frac{2(k_C S_C)}{2(k_C S_C) - R_T (k_H S_H) \tan(\theta)}}$$

$$\Delta L_{00} = \frac{\Delta L'}{k_L S_L}$$

$$\Delta C_{00} = \frac{\Delta C''}{S_C''}$$

$$\Delta H_{00} = \frac{\Delta H''}{S_H''}$$

The worked examples: Luo *et al.*

$x_0=94.811$, $y_0=100.00$, $z_0=107.304$

Pair	X	Y	Z	L'	a'	b'	C'	h'	G	T	S_L	S_C	S_H	R_T	ΔE_{00}
1	19.4100	28.4100	11.5766	60.2574	-34.0678	36.2677	49.7590	133.21	0.0017	1.3010	1.1427	3.2946	1.9951	0.0000	1.2644
	19.5525	28.6400	10.5791	60.4626	-34.2333	39.4387	52.2238	130.96							
2	22.4800	31.6000	38.4800	63.0109	-32.6195	-5.8663	33.1428	190.20	0.0490	0.9402	1.1831	2.4549	1.4560	0.0000	1.2630
	22.5833	31.3700	36.7901	62.8187	-31.2542	-4.0864	31.5202	187.45							
3	28.9950	29.5800	35.7500	61.2901	5.5669	-5.3901	7.7488	315.92	0.4966	0.6952	1.1586	1.3092	1.0717	-0.0032	1.8731
	28.7704	29.7400	35.6045	61.4292	3.3643	-4.9620	5.9950	304.14							
4	4.1400	8.5400	8.0300	35.0831	-44.3939	3.7933	44.5557	175.12	0.0063	1.0168	1.2148	2.9105	1.6476	0.0000	1.8645
	4.4129	8.5100	8.6453	35.0232	-40.3237	1.5901	40.3550	177.74							
5	4.9600	3.7200	19.5900	22.7233	20.1424	-46.6940	50.8532	293.33	0.0026	0.3636	1.4014	3.1597	1.2617	-1.2537	2.0373
	4.6651	3.8100	17.7848	23.0331	15.0118	-42.5619	45.1317	289.43							
6	15.6000	9.2500	5.0200	36.4612	47.9197	18.3852	51.3256	20.99	0.0013	0.9239	1.1943	3.3888	1.7357	0.0000	1.4146
	15.9148	9.1500	4.3872	36.2715	50.5717	21.2231	54.8444	22.77							
7	73.0000	78.0500	81.8000	90.8027	-3.1244	1.4410	3.4407	155.24	0.4999	1.1546	1.6110	1.1329	1.0511	0.0000	1.4440
	73.9351	78.8200	84.5156	91.1528	-2.4651	0.0447	2.4655	178.96							
8	73.9950	78.3200	85.3060	90.9257	-0.8108	-0.9208	1.2269	228.63	0.5000	1.3916	1.5930	1.0620	1.0288	0.0000	1.5381
	69.1762	73.4000	79.7130	88.6381	-1.3477	-0.7239	1.5298	208.24							
9	0.7040	0.7500	0.9720	6.7747	-0.4362	-2.4247	2.4636	259.80	0.4999	0.9556	1.6517	1.1057	1.0337	-0.0004	0.6378
	0.613873	0.6500	0.851025	5.8714	-0.1477	-2.2286	2.2335	266.21							
10	0.2200	0.2300	0.3250	2.0776	0.1192	-1.1350	1.1412	275.99	0.5000	0.7827	1.7246	1.0383	1.0100	0.0000	0.9082
	0.093262	0.1000	0.145292	0.9033	-0.0954	-0.5514	0.5595	260.18							

