



國立中央大學



光與照明國際最新標準與技術發展現況研討會

CIE 演色性評估指標

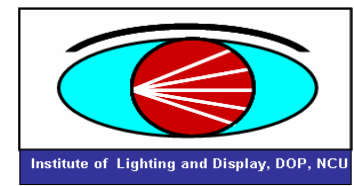
楊 宗 勳 教授

國立中央大學

光電科學與工程學系

照明與顯示科學研究所

2019/10/25



Improving CRI

- TC1-33, TC1-62, TC1-69

- TC1-90

Colour Fidelity Index

- TC1-91

Methods for Evaluating the Colour Quality of
White-Light Sources

TECHNICAL REPORT

**CIE 2017 Colour Fidelity Index
for accurate scientific use**

CIE 224:2017

UDC: 159.937.51
535.67
612.843.31
535.66

Descriptor: Perception of colour
Colour of objects
Colour vision
Colorimetry

光與照明國際最新標準與技術發展現況研討會

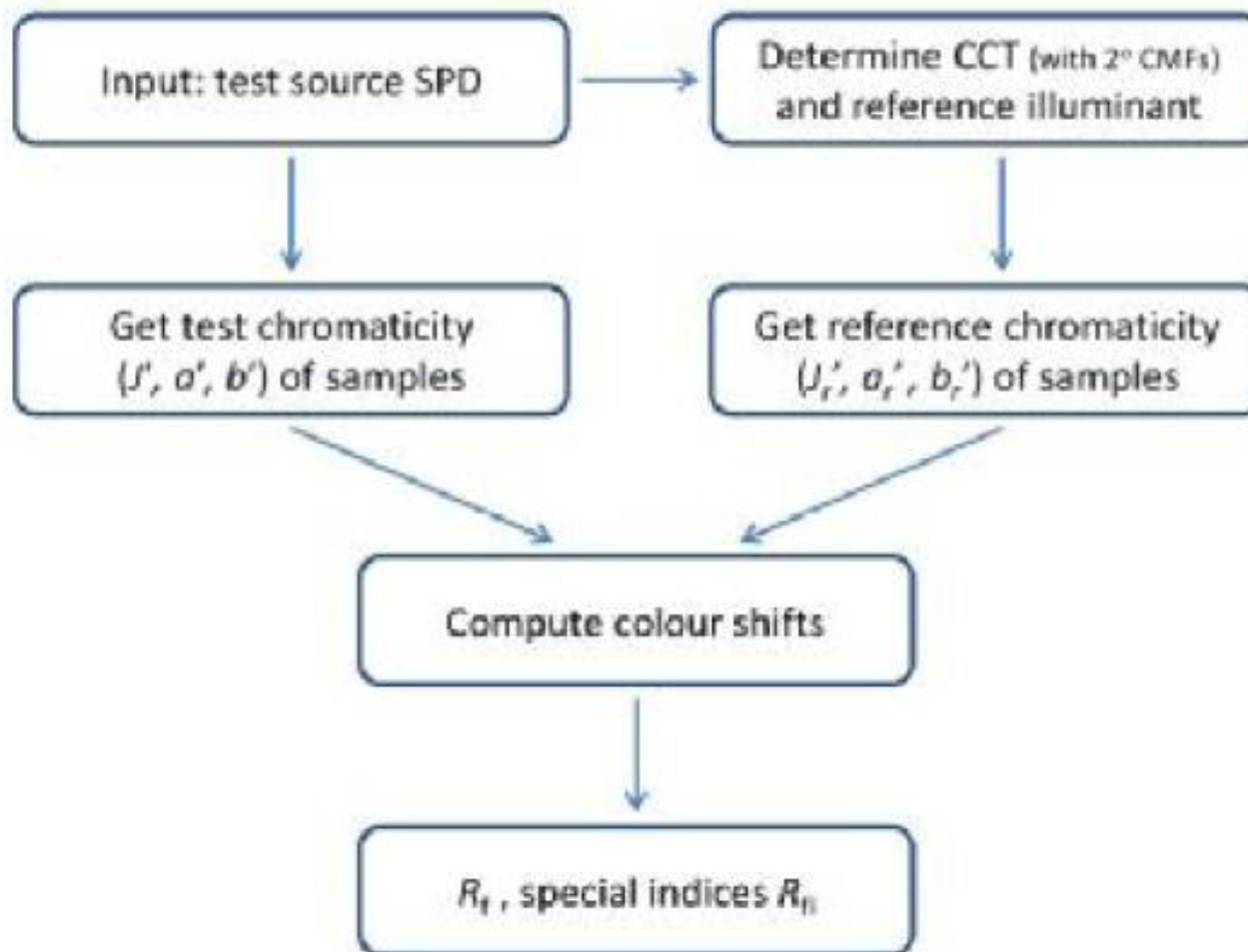
Color Fidelity

- Degree to which a light source causes a shift in the color appearance of a surface it illuminates, relative to that surface's color appearance when illuminated by a defined reference illuminant, and whereby the magnitude of the color shift is assessed by considering the shifts along all three cardinal axes of the color appearance space

Color Fidelity Index

- Implementation of CAM02UCS color space
- Development of an improved sample set
- Avoiding negative values for the CFIs
- Minor change to reference illuminants of CCT 4000K~5000K
- Rescaling of average color shifts
- Output format

Calculation Flow



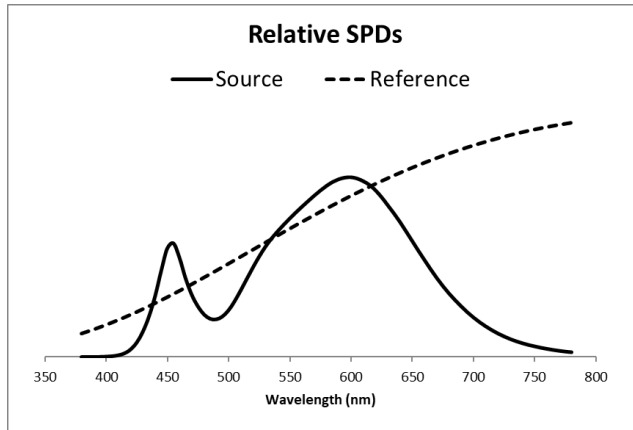
光與照明國際最新標準與技術發展現況研討會

Test Color Samples



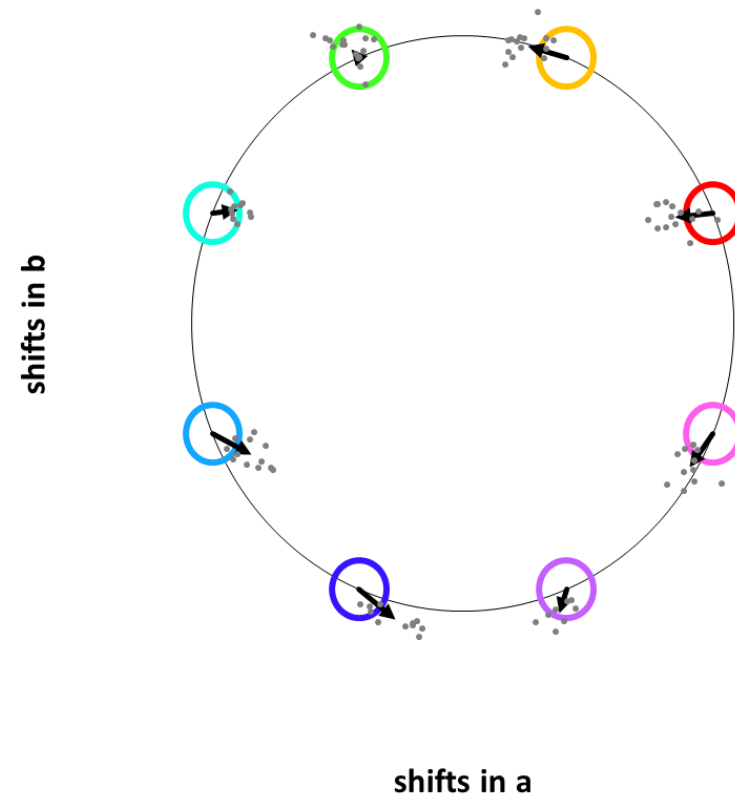
Hue Bin Number	Hue Angle Range under 5 000 K CCT	Colour Evaluation Sample # Range
1	0° to 45°	TCS#01 to TCS#14
2	45° to 90°	TCS#15 to TCS#30
3	90° to 135°	TCS#31 to TCS#47
4	135° to 180°	TCS#48 to TCS#57
5	180° to 225°	TCS#58 to TCS#69
6	225° to 270°	TCS#70 to TCS#80
7	275° to 315°	TCS#81 to TCS#88
8	315° to 360°	TCS#89 to TCS#99

光與照明國際最新標準與技術發展現況研討會



Rf	Rf1	Rf2	Rf3	Rf4	Rf5	Rf6	Rf7	Rf8	Rf9
81.6	89.5	80.5	81.5	79.4	65.9	79.4	73.2	68.5	95.9
Rf10	Rf11	Rf12	Rf13	Rf14	Rf15	Rf16	Rf17	Rf18	Rf19
76.3	71.9	71.8	83.3	93.0	89.2	72.9	75.1	85.8	75.1
Rf20	Rf21	Rf22	Rf23	Rf24	Rf25	Rf26	Rf27	Rf28	Rf29
63.4	69.4	71.4	89.7	76.8	67.6	75.5	92.7	87.7	81.1
Rf30	Rf31	Rf32	Rf33	Rf34	Rf35	Rf36	Rf37	Rf38	Rf39
95.0	83.3	74.4	90.4	80.4	89.0	86.9	85.0	95.7	98.5
Rf40	Rf41	Rf42	Rf43	Rf44	Rf45	Rf46	Rf47	Rf48	Rf49
96.3	98.7	88.4	85.2	99.6	90.4	88.6	94.3	85.3	86.4
Rf50	Rf51	Rf52	Rf53	Rf54	Rf55	Rf56	Rf57	Rf58	Rf59
90.0	89.3	88.0	83.6	89.6	86.7	81.4	80.2	80.6	88.5
Rf60	Rf61	Rf62	Rf63	Rf64	Rf65	Rf66	Rf67	Rf68	Rf69
89.7	84.2	84.2	79.4	71.3	72.8	65.8	64.1	71.7	77.4
Rf70	Rf71	Rf72	Rf73	Rf74	Rf75	Rf76	Rf77	Rf78	Rf79
68.0	63.2	87.1	62.4	92.7	67.3	67.6	80.0	70.4	89.0
Rf80	Rf81	Rf82	Rf83	Rf84	Rf85	Rf86	Rf87	Rf88	Rf89
87.0	81.5	94.2	94.3	89.4	79.3	76.6	83.7	87.7	76.7
Rf90	Rf91	Rf92	Rf93	Rf94	Rf95	Rf96	Rf97	Rf98	Rf99
88.6	76.2	68.5	80.1	65.3	74.9	83.9	88.6	84.2	77.4

Figure B1 from CIE 224 - 2017

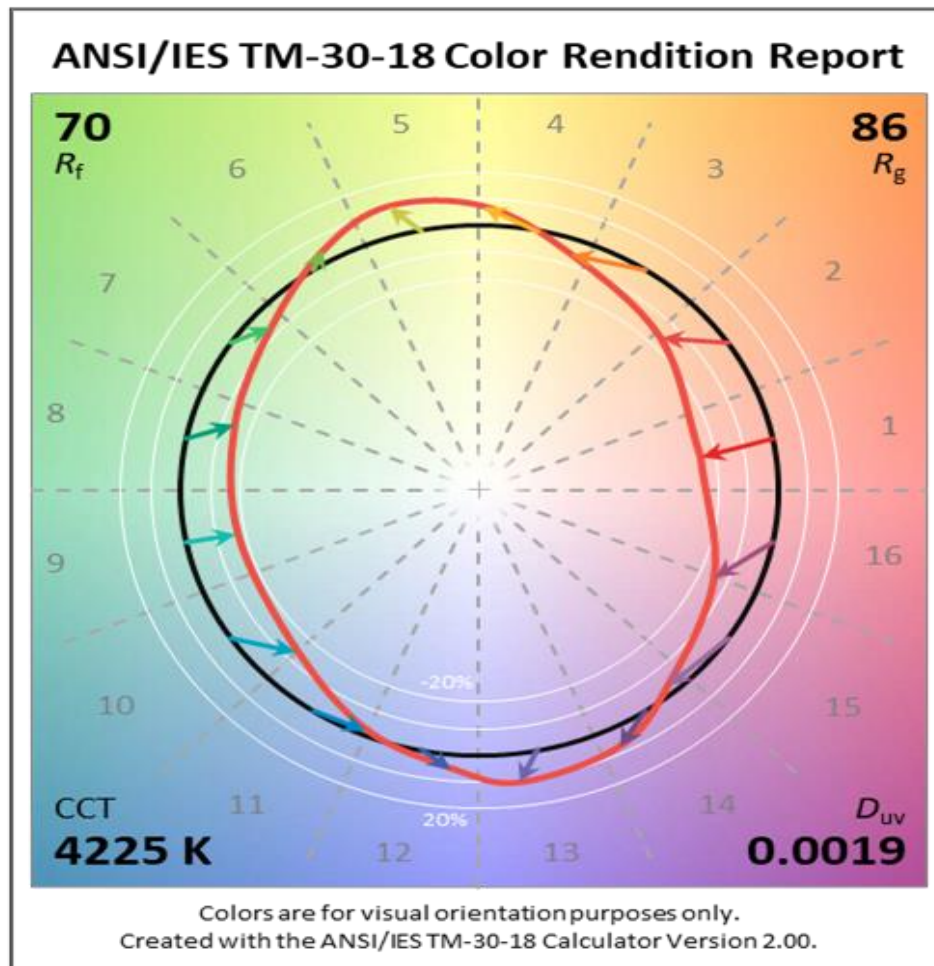


- Overview Of Methods For Evaluating Colour Rendition Of White-light Sources Beyond Colour Fidelity
- DRAFT NO. 7.0
- DATE: 2019-07-10

Available Methods

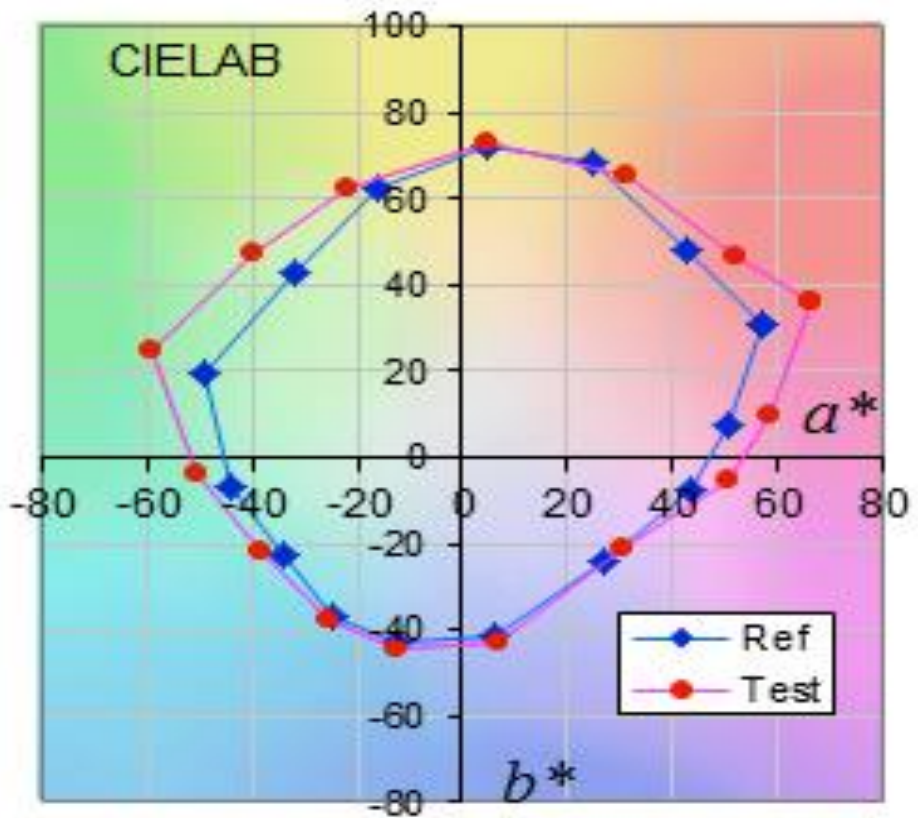
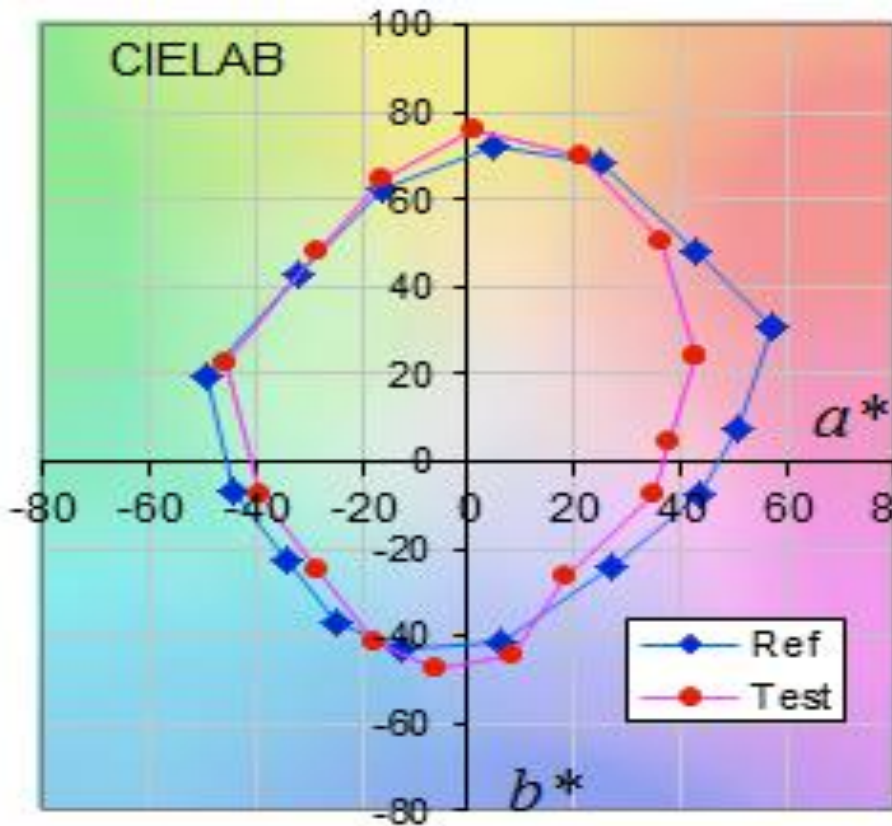
1. ANSI/IES TM-30-18
2. Color Quality Scale (CQS)
3. CRI-based color rendition properties (CRI-CRP)
4. Color rendering vectors and color saturation icon
5. Feeling of Contrast Index (FCI)
6. Memory Color Rendition Index (MCRI)
7. Preference index of Japanese Skin Color (PS)

$$R_g = 100 \times \frac{A_t}{A_r}$$



Color Quality Scale (CQS)

15 saturated TCS



光與照明國際最新標準與技術發展現況研討會

Application of CIE 13.3-1995 with Associated CRI-based Colour Rendition Properties

December 2018

© Global Lighting Association 2018

光與照明國際最新標準與技術發展現況研討會

Output of GLA Calculation Tool for CIE 13.3 CRI and Associated CRI-based Colour Rendition Properties

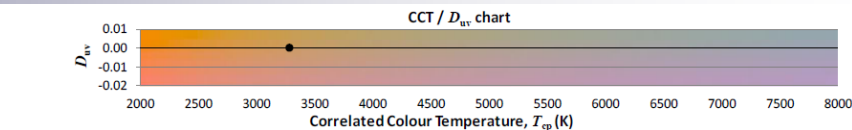
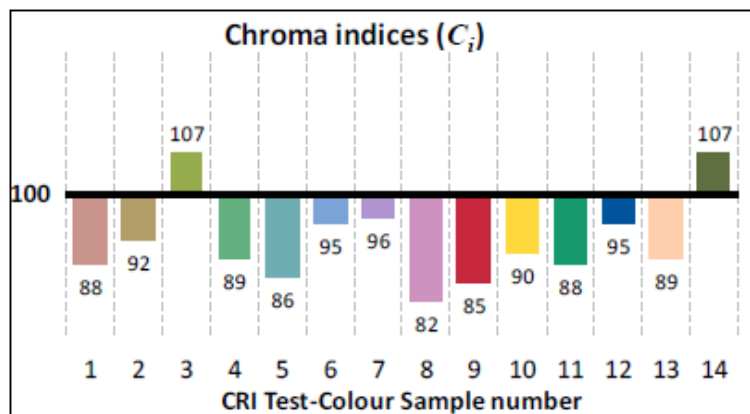
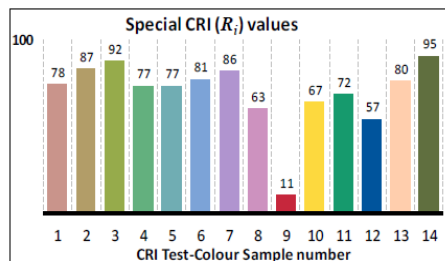
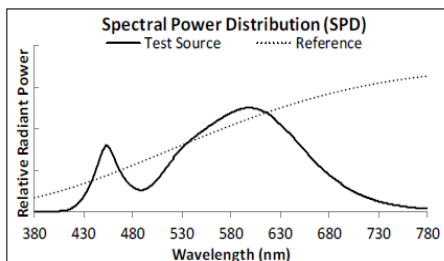
Test Source: Example (CIE 224) LED spectrum

Notes: From CIE 2017 Colour Fidelity Index Calculator 1 nm - V.3(2017-07-15).xlsx

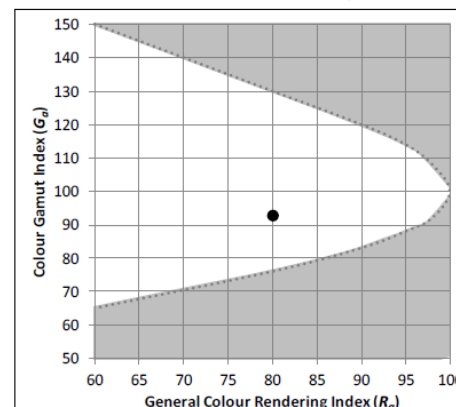
Date / Time: Friday, December 7, 2018

12:55:53 PM

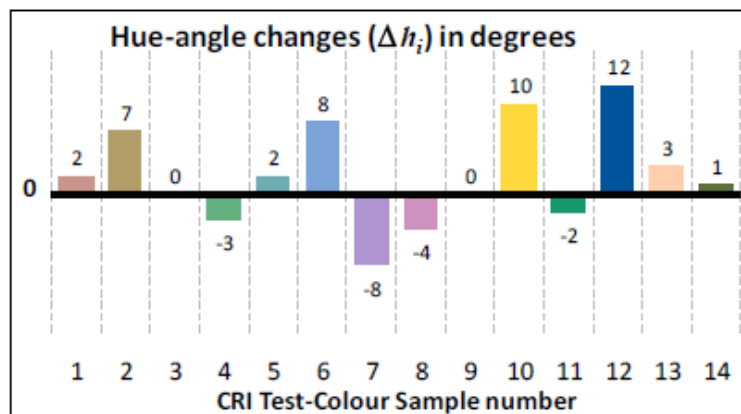
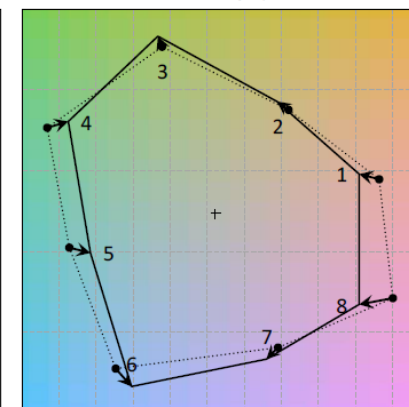
Correlated Colour Temperature (T_{cp}) in K	3288	CIE1931 chromaticity coordinate, x	0.4174
Distance to Blackbody Locus (D_{95})	-0.0003	CIE1931 chromaticity coordinate, y	0.3957
General Colour Rendering Index (R_a)	80	CIE1976 chromaticity coordinate, u'	0.2415
Colour Gamut Index (G_a)	93	CIE1976 chromaticity coordinate, v'	0.5151



Two-dimensional R_a - G_a Graphic

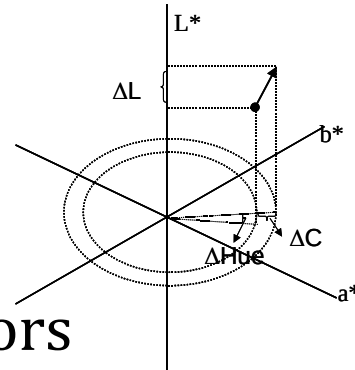
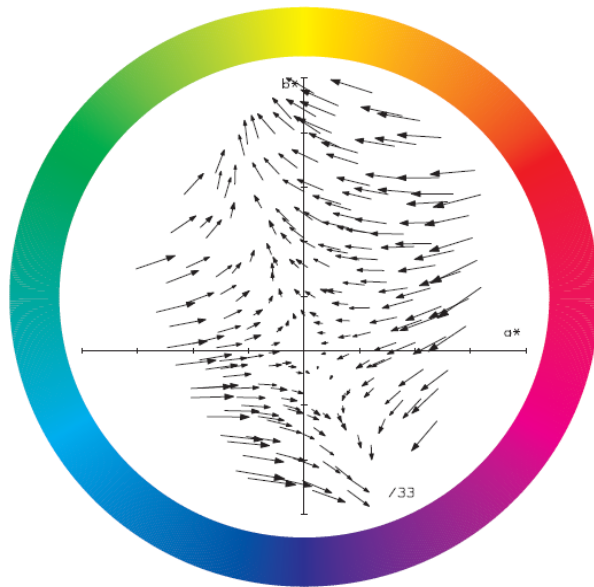


Colour-shift graphic

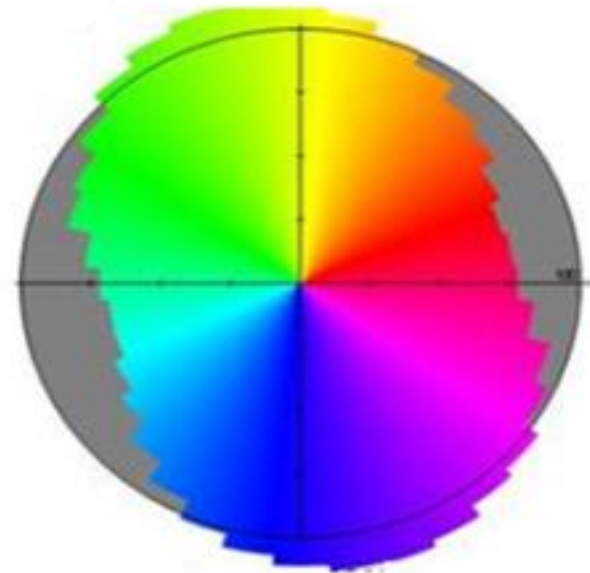


光與照明國際最新標準與技術發展現況研討會

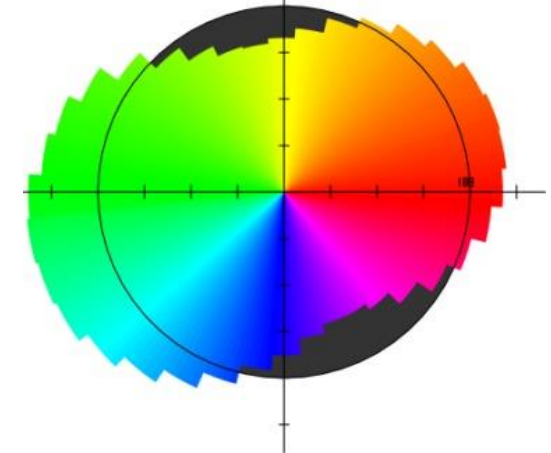
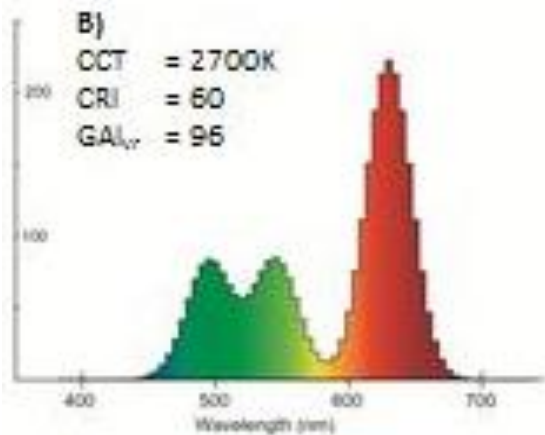
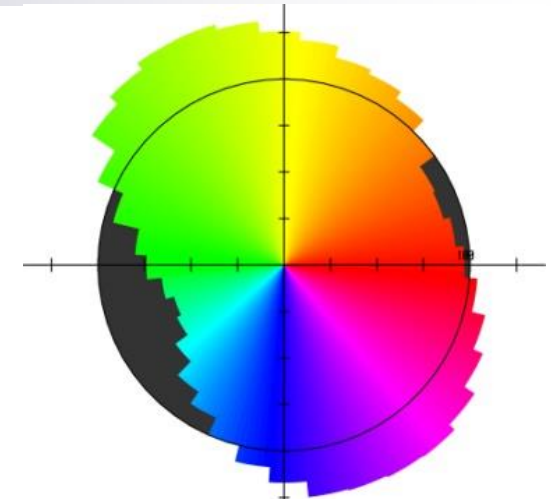
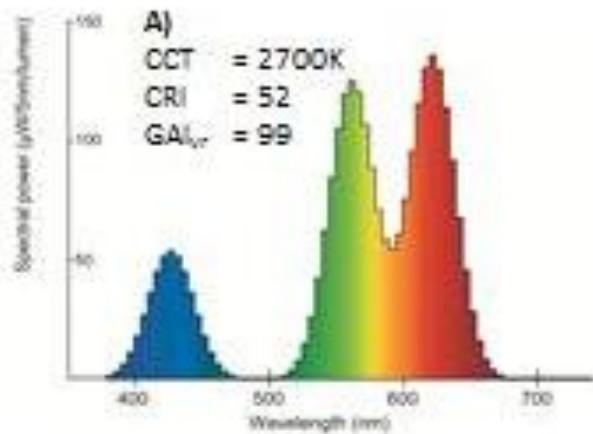
Colour rendering vectors



colour saturation icon



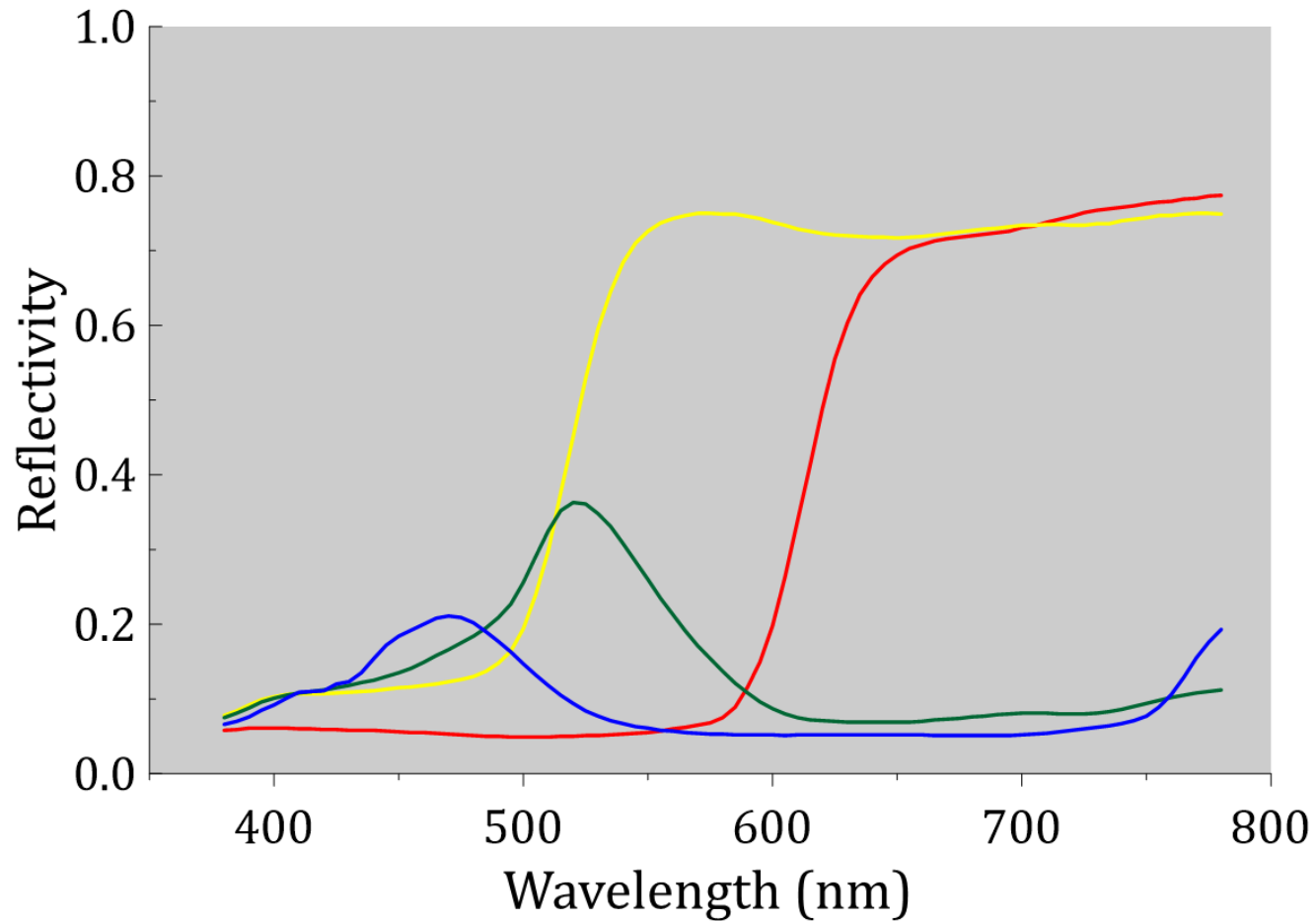
光與照明國際最新標準與技術發展現況研討會



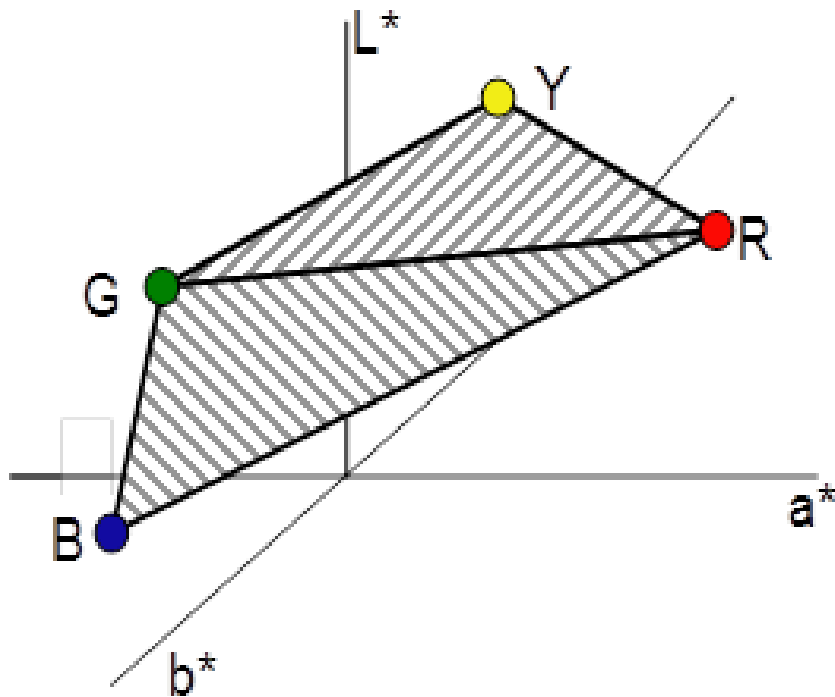
光與照明國際最新標準與技術發展現況研討會

Feeling of Contrast Index (FCI)

16



光與照明國際最新標準與技術發展現況研討會



$$FCI = \left(\frac{G(T)}{G(D_{65})} \right)^{1.5} \times 100$$

Degree of similarity

$$S_i(P_i, T_i) = e^{-(1/2)[a_{i,3}(P_i - a_{i,1})^2 + 2a_{i,5}(P_i - a_{i,1})(T_i - a_{i,2}) + a_{i,4}(T_i - a_{i,2})^2]}$$

$$(i = 1, \dots, 10)$$

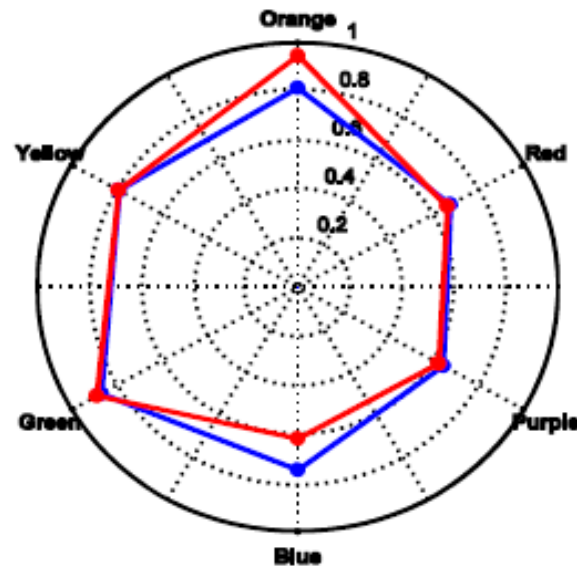
parameters $a_{i,1}$ - $a_{i,5}$, describe the location (memory colour chromaticity), shape, size and orientation of the similarity functions

$$S_a = \sqrt[n]{S_1 \cdot S_2 \cdot \dots \cdot S_n}$$

$$R_m = 100 \cdot \left(\frac{2}{e^{p_1 |\ln(S_a)|^{p_2} + 1}} \right)^{p_3}$$



Memory Colour Quality Index



Illuminant D65

Sa = 0.775

S-ap = 0.783
S-ba = 0.914
S-or = 0.888
S-la = 0.645
S-sm = 0.690
S-sy = 0.677
S-sc = 0.974
S-cf = 0.686
S-ha = 0.749
S-n4 = 0.812

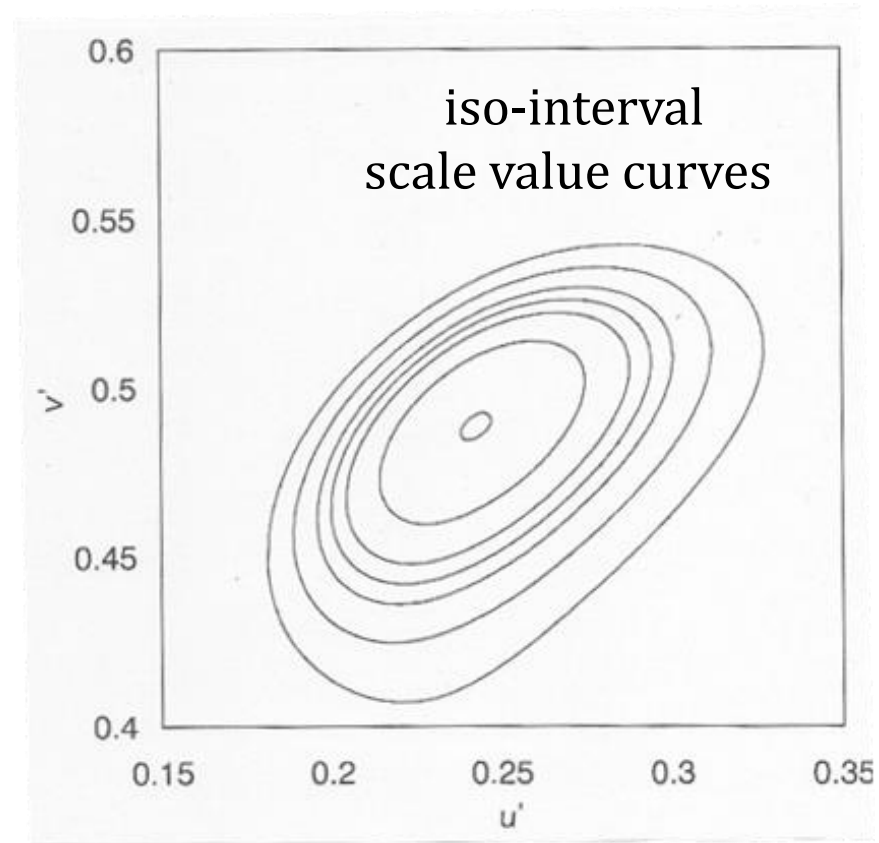
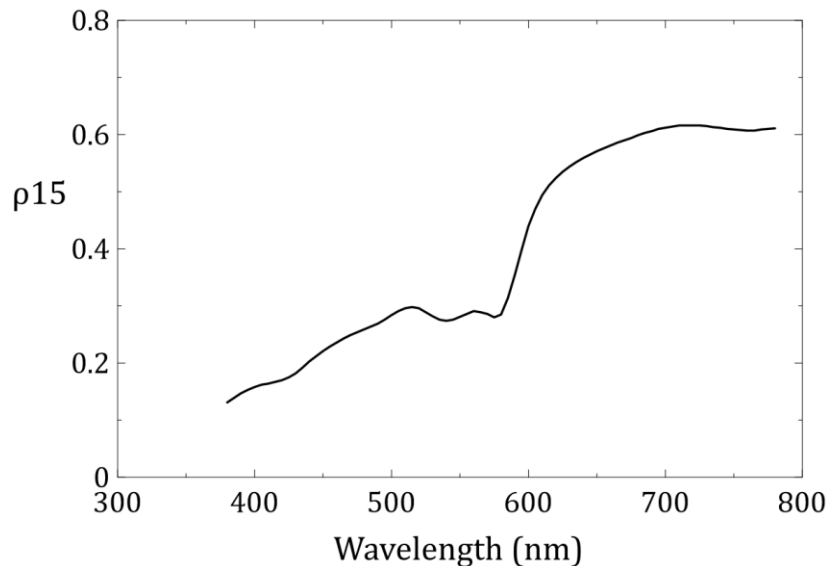
Illuminant A

Sa = 0.768

S-ap = 0.810
S-ba = 0.927
S-or = 0.938
S-la = 0.624
S-sm = 0.711
S-sy = 0.662
S-sc = 0.981
S-cf = 0.680
S-ha = 0.955
S-n4 = 0.541

光與照明國際最新標準與技術發展現況研討會

Preference index of Japanese Skin Color (PS)



光與照明國際最新標準與技術發展現況研討會

$$P = 446.846 + 2024u' + 145u'^2 + 8689u'^3 - 4318v' \\ - 8719u'v' - 16082u'^2v' + 12260v'^2 + 18608u'v'^2 - 12579v'^3$$

$$PS = 4 \times 5^P$$



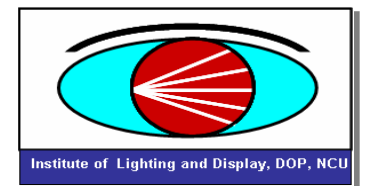
NCU NCU

國立中央大學



光與照明國際最新標準與技術發展現況研討會

Thanks for your attention



2019/10/25