

PWDAS-39

OUTPUT LINEARIZATION IN CIELAB FOR VISUAL DISPLAYS WITH EIGHT DIFFERENT LUMINANCE REFLECTIONS OF INDOOR ILLUMINANTS

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Introduction

ISO 9241-306:2008 uses the achromatic test chart of ISO/IEC 15775 for output linearization in CIELAB for displays at office work places. The display is either a monitor or a projection display. The indoor illuminant produces luminance reflections on the display which depend on the reflection properties of the display. The relative luminance between black and white is very different for the visual displays. In a worse case the luminance of the projector and the CIE indoor daylight iD65 may be equal on the display. Then the relative luminance is 0,5:1 on the display between black and white. In a black room without indoor illumination the relative luminance is 0,0:1, but in offices 500 lux indoor illumination is standard. According to ISO 9241-306 then the reflection ratio is 2,5:90 = 1/36:1 = 0,028:1 (less than 3% luminance of black compared to white).

Effect of indoor illuminance on grey and colour series and output linearization

There are large effects on the achromatic and chromatic colour series by the indoor illuminants, for example by the artificial or the CIE indoor illuminants iD65 or iD50 of CIE TC1-66 (CIE-publ. in print). ISO 9241-306 defines a PDF file to test the illuminant effect with a 16 step grey scale, see <http://www.ps.bam.de/9241E> According to ISO 9241 306 the output of the 16 steps should be equally spaced at work places. In a live demonstration at this CIE meeting a tool is used to make this happen with the indoor illumination and the projector used during the presentation of this paper. There is also a file which simulates the effect of eight luminance reflections of the indoor illuminant.

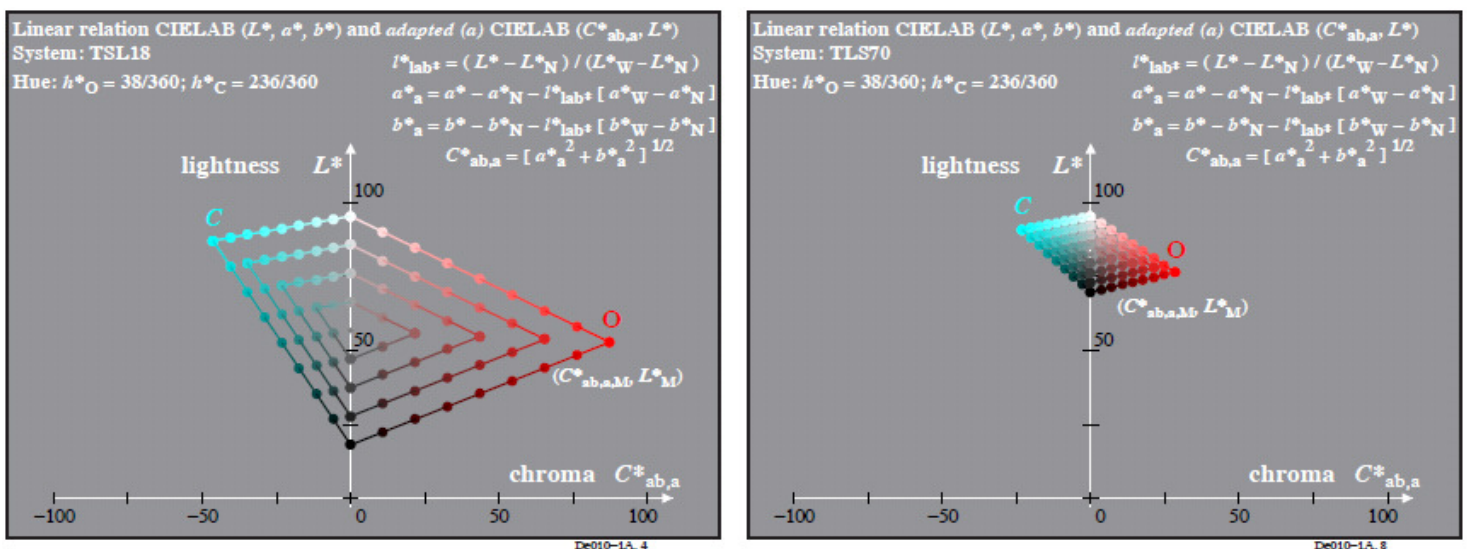


Figure 1: CIELAB (C^*_{ab} , L^*) diagram for colour series O - C and two relative luminances

Fig. 1 shows the complementary colour series *O* – *C* for the standard luminous reflectance ratios 2,5:90 and 45:90 between Black *N* and White *W* in CIELAB (C^*_{ab}, L^*) diagrams.

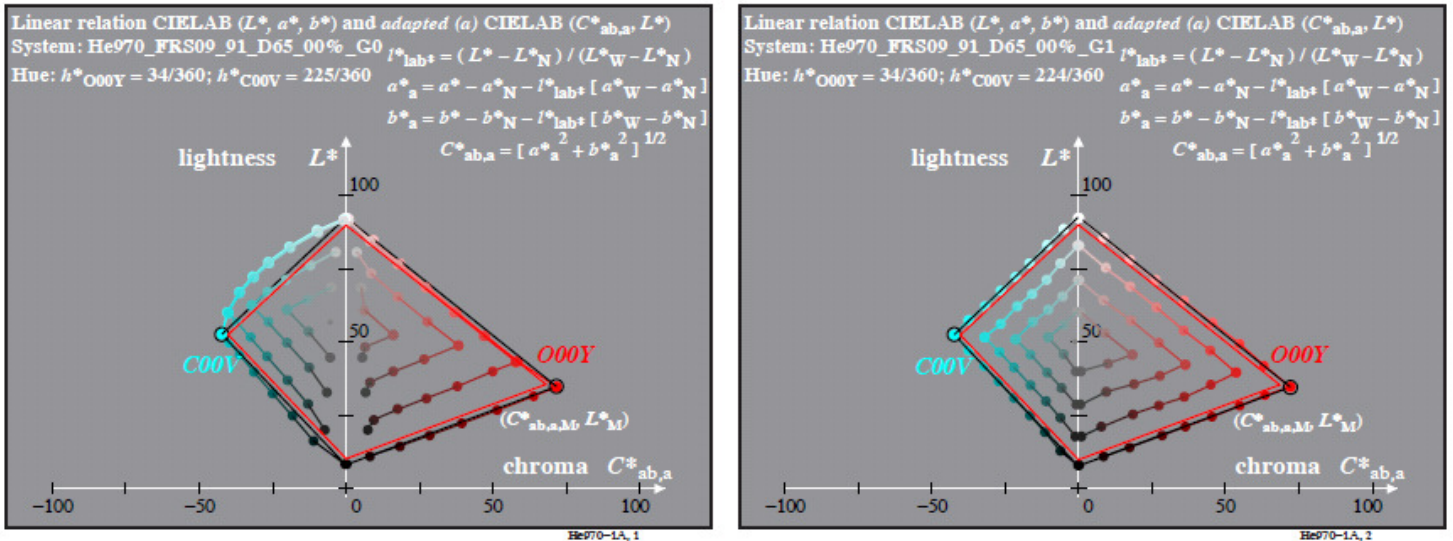


Figure 2: Start output (left) and linearised output of a photo printer (right)

Fig. 2 shows a start output (left) and linearised (right) output of a photo printer. The start output produces for example irregular chromatic grey colours, and the first two steps near White *W* are equal. The linearized output produces the intended equally spaced achromatic grey and chroma scales. To reach this goal a transformation table rgb to rgb' for output linearization is necessary, see ISO/IEC TR 19797. This ISO document recommends output linearization prior to any useful colour management method. The result is Fig 2. uses output linearization by a three dimensional table with a 9x9x9 grid of regular spaced rgb values in the file, for example with $r = 0, 1/8, \dots, 7/8, \text{ and } 1$, and the measured CIELAB data L^*, a^*, b^* of this output. Often only professional output processes use output linearization. This is one reason that standard ICC colour management according to ISO 15076-1 fails to a high degree with colour office devices, see Fig. 2 (left).

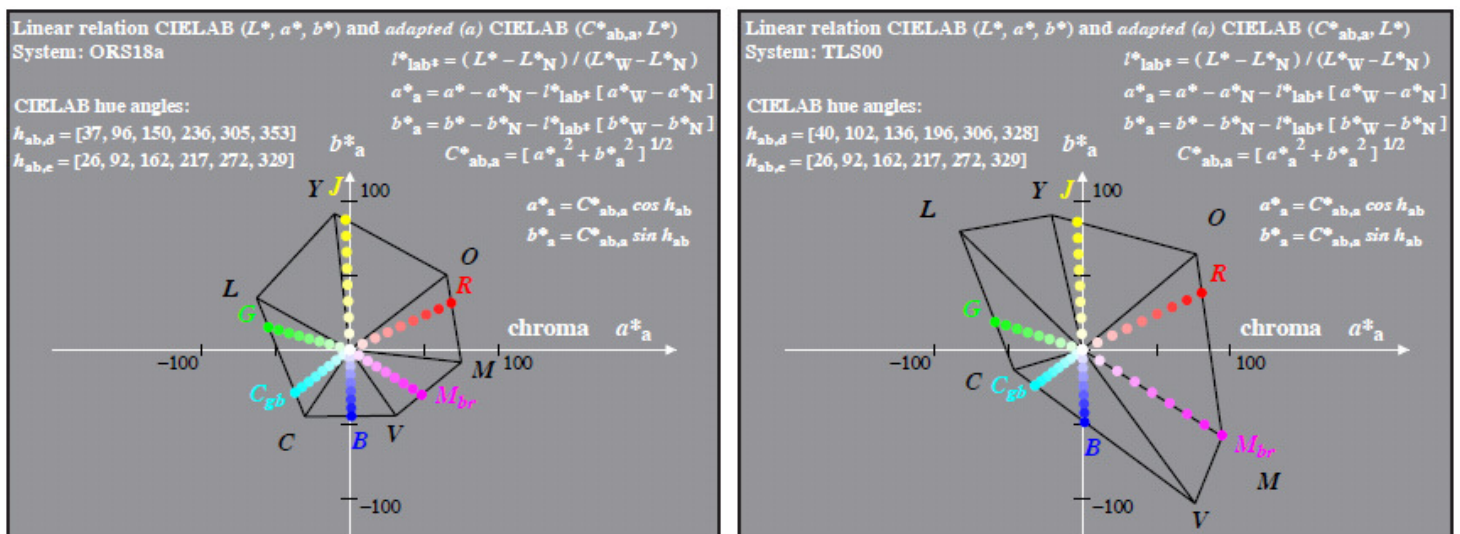


Figure 3: Offset (left) and CRT monitor output (right) compared to elementary hue output

Fig. 3 shows a standard offset print (left) and a CRT monitor output (right) (device colours *OYLCVM* in black letters) compared to elementary hue output of *RJGB*. The device independent elementary (e) hue angles, for example of *J* (= Yellow = Jaune), and the device (d) dependent hue angles are given in Fig. 3. For three display technologies (CRT, LCD, OLED) the device hue angles are 305, 270 and about 240 degrees. The device hue differences of "Violett blue *V*" is 65 degrees and similar compared to the hue angle difference of 62 degrees between Red *R* and Yellow *J*. It is intended that the next revision of ISO 9241-306 will include improved methods for output linearization and additionally a device independent hue output, for example the Blue *B* with the CIELAB hue angle 272 degree will be produced for the input data *rgb* = 0, 0, and 1. The paper will describe the application of the linearization tables between *rgb* and *rgb'* to reach linearization for 8 indoor illumination conditions in offices to be used by *PostScript* code or with "device link profiles". Additionally some problems of a mixed illumination will be discussed. For example a D65 display with a 2,5% reflection of the CIE D50 or A indoor illuminations produce a yellowish Black *N* ($b^* = 10$ and 20) and approximately no chroma change for White *W*. In contrast *N* and *W* on paper are both shifted from the chromaticity of D65 to the chromaticity of D50 or A.

References

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- ISO 9241-306:2008, Ergonomics of human-system interaction — Part 306: Field assessment methods for electronic visual displays.
- ISO/IEC 15775:1999 and Adm1 2005, Colour reproduction properties of colour copiers.
- ISO/IEC TR 19797:2004, Device output of 16-step colour scales, output linearization method (LM) and specification of the reproduction properties, see a public version (20 pages, 280 kByte) <http://www.jbmia.or.jp/sc28/sc28docs/j28n656.zip>
- ISO/IEC TR 24705:2005, Method of specifying image reproduction of colour devices by digital and analog test charts, see a public version (80 pages, 1 Mbyte) <http://www.jbmia.or.jp/sc28/sc28docs/j28n689.zip>
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- Richter, Klaus (2008), Ergonomic colour image technology with high visual and material efficiency based on elementary (unique) hues, 259-264, 16th Color Imaging conference, Portland, 2009