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Colorimetric scan, display, and print for archiving based on the ergonomic International Standard ISO 9241-306:2018 at work places

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Abstract

ISO 9241-306:2018 shows colorimetric methods for output optimization of displays and projectors at work places. The optimization by equal spacing of colour series, visibility and readability is intended. There are input linearization methods for scanners and photography and output linearization methods for displays, printers, and offset print. By a start output of a "digital" ISO-test chart with 729 colours (9x9x9 rgb values) for example the loop "ISO-standard file -> ISO-print -> ISO-scan -> ISO-file" is closed and the rgb* colour data of the original ISO-file are approximately reproduced at the end of the loop. For any hue there is a linear relation in both directions between the rgb* and the CIELAB LCh* data. The closed loop and the linear relations are important properties for archiving.*

Motivation and Problem

In applications there are many different colour devices for output (displays, projectors, printers, offset machines) and input (scanners, cameras). All devices can produce any hue. However, the colour gamut is different. The user wish of a common colour appearance are often solved, if the colour differences of equally spaced samples remain visually equally spaced on any device.

The colours on displays change by a high degree by the reflection of the ambient light on the display. For example in a room with much daylight for projector displays the luminance contrast between White W and Black N may be only 2:1 instead of the standard case 36:1. After linearization in the two cases the 15 colour differences of the 16 step gray scale have colour differences ΔL^*=1,7 and 5,2. The threshold is near ΔL^*=1 according to CIE 230, and all steps can be distinguished. Effective input and output linearization methods [2] are now available and are based on the measurement of 729 (=9x9x9) colours on any device. The standard [1] allows to download one achromatic and 5 chromatic test charts for free from the ISO server. The "digital" and "analog" test charts AE49 are intended for measurement of the *rgb** and CIELAB data.

Approach

If we start with the ISO file (see the URL in Fig. 1), output linearization produces a hardcopy, for example in offset print. The relative CIELAB differences are equal for the 9 step colour series between W and N, W and C (full colour), and N and C. A visual evaluation and/or a colorimetric specification can confirm this for the ISO file. Therefore there i a linear relation between the CIELAB *LCh** values and the *rgb* values which are called metric *rgb** data. A star indicates the equal relative spacing similar as in CIELAB. For the range $0 < rgb^* < 1$ there is a linear relation to CIELAB L^* in the range between L^*_N and L^*_W of Black and White.

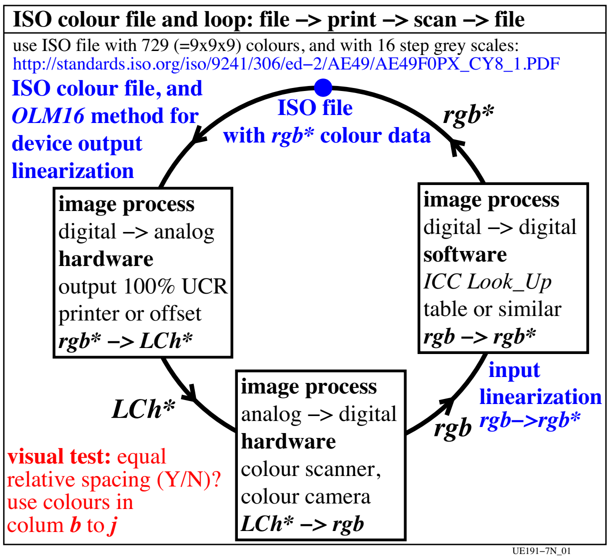
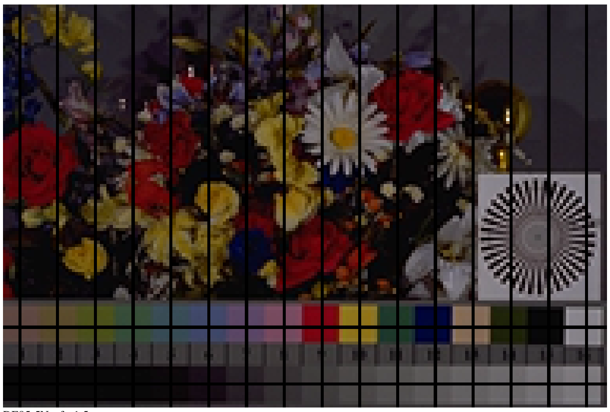


Figure 1. *Loop for corresponding colour appearance based on equal relative colour differences in CIELAB*

If a photographic camera takes a 16 step equally spaced gray scale between L^*=20 and L^*=95 with a lightness difference of ΔL^*=5, then the device (d) rgb_d data depend on the exposure. An under exposure of 1,5 stops produce the raw and linearized image shown in Fig. 2 and 3, respectively.

The grid in Fig. 2 shows the position for rgb_d "measurement" of the display output. There are tools for this of the computer operating systems. In Fig. 2 for the series Black N to White W the rgb_d data are in the range 0 to 1, and usually monotonic functions with smaller steps near Black N compared to the *rgb** values in the same range. The 16 device rgb_d data are transferred to these *rgb** data. Fig 3 shows the result of this output linearization.

For slide film the *visual* result is very similar for all exposures between -1,5 stops and +1,5 stops. For negative film the *visual* result is similar for a larger range between -2 stops and +4 stops. Some results for both cases will be shown at the poster presentation.



DE85-5N; sf; -1,5 stop

Figure 2. *Flower image taken with slide film (sf) and 1,5 stop under exposure.*

DE85-7N; sf; -1,5 stop

Figure 3. *Linearized image of slide film (sf) and 1,5 stop under exposure*

Result and Conclusions

Figure 4 shows *cmy0** values for the print output with the colours cyan c^*, magenta m^*, yellow y^* and black n^*. By the *1-minus-relation* $r^*=1-c^*$, $g^*=1-m^*$, and $b^*=1-y^*$ the four values in Fig. 4 can be replaced by three values *rgb**. The OLM16 method [2] calculates the device values $cmyn_d$ for the equally spaced CIELAB output. For the production of the *Relative Elementary Colour System* RECS [3] the colour measurement of the test chart AE49 was done at the offset machine. The linearized production started soon after the exposure of the four separation plates. For the mean gray Z instead of $cmy0_d$ = (0,5 0,5 0,5 0,0) the values $0myn_d$ = (0,0 0,01 0,03, 0,57) produce the gray lightness L^*_Z =56 (mean between L^*_N =18 and L^*_W =95) by 100% *Under Colour Removal* (UCR).

Therefore the gray and all colours nearby are approximately printed by only the achromatic colour with a high achromatic stability. This and the high offset gamut are important properties for the input linearization of scanners and cameras.

Output and input linearization within the loop of Fig. 1 produces approximately back the original *rgb** data of the ISO file. In application for any device an index based table can transfer the *rgb** data of 16,7 (256x256x256) million colours to the rgb_d data for a display output or the $cmyn_d$ data for a print output, and all data within the range 0 to 1. The transfer with a raster image processor (RIP) seems available for (fast video) display or print(er) output.

According to [5] the *rgb** encoding within the 8bit range 64 < *rgb** < 191 is visually sufficient, because the L^* threshold is near 1 and the L^* range is less than 77. This allows to specify colours outside the standard offset triangles by the use of the linear relation between *rgb** and *LCh** data. Then a wide gamut colour area is within the standard range 0 < *rgb** < 255.

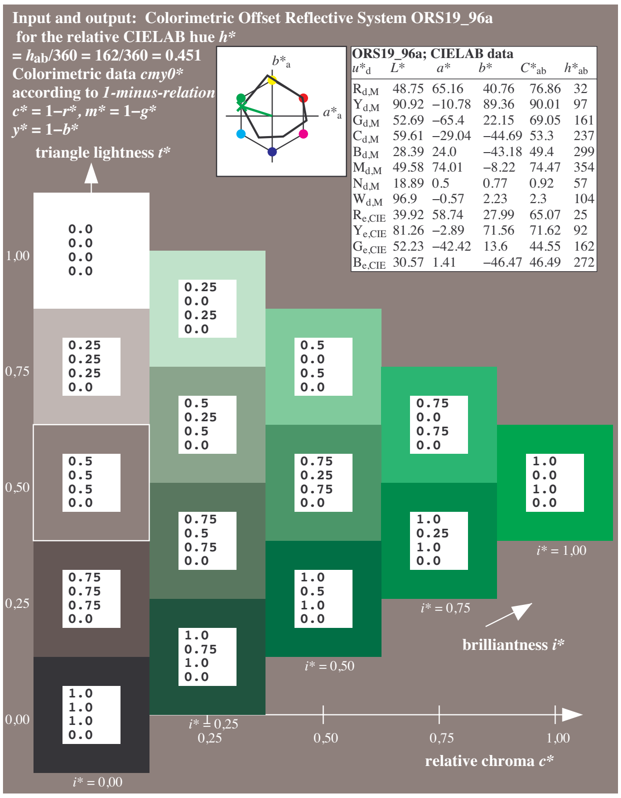


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Figure 4. *Colour values cmy0* of 5 step colour series for a green hue.*

References

[1] ISO EN 9241-306:2018, Ergonomics of human-system interaction - Part 306: Field assessment methods for electronic visual displays, for many ISO-test charts with questions about output properties on displays, see http://standards.iso.org/iso/9241/306/ed-2/index.html

[2] K. Richter, Output Linearization Method OLM16 for Displays, Offset, and Printers (2016), see (60 pages, 2 MB) http://farbe.li.tu-berlin.de/OUTLIN16_01.PDF

[3] K. Richter, Relative Elementary Colour System RECS (2008), (includes ISO/IEC-test charts of [1] in offset print) see http://farbe.li.tu-berlin.de/A/RECS.html

[4] K. Richter, Colour and colour vision, elementary colours in image technology, (includes ISO/IEC-test charts of [1] in the printed offset version), see (80 pages, 2 MB) http://standards.iso.org/iso/9241/306/ed-2/ES15.PDF

[5] CIE 230:2019, Validity of formulae for small colour differences.

Author Biography

The author has a PhD degree in physics from the University of Basle (Switzerland). He is retired and teached colorimetry and image technology [4] at the Berlin University of Technology, see the URL http://farbe.li.tu-berlin.de/.