Relative Colorimetric System (RCS) based on device and elementary colours

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ABSTRACT

The Relative Colorimetric System (RCS) includes a method for the specification of both digital and analog colours by three *relative* colorimetric colour coordinates brilliantness *i** (equal to 1 minus blackness *n*)*, relative chroma *c**, and elementary (unique) hue text *u**, for example the specification *icu** = (1, 1, R25J). If these coordinates or equivalent coordinates *rgb** = (1, 0,25, 0) are given together with eight reference device colours in CIELAB, then the CIELAB coordinates can be calculated for any device. If the CIELAB data of an analog colour are given, either the data *LAB** =(*L*, a*, b**) or the equivalent data *LCH** = (L^*, C^*_{ab}, h_{ab}), then the equivalent digital data *icu** or the equivalent data *rgb** can be calculated which are called the digital colour data and which are used in image technology. The Relative Colorimetric Systems (RCS) uses the elementary hues specified by the CIE test colours no. 9 to 12 of CIE 13.3. Further for any device the six chromatic colours OYLCVM and black N and White W are necessary as reference points, for example the eight reference colours of the standard Offset Reference System ORS18 defined in ISO/IEC 15775. Applications of the RCS are included in ISO/IEC TR 24705 and DIN E 33872-1 to -6.

1. INTRODUCTION

ISO/IEC 15775 defines colour names, the CIELAB data (L^*, a^*, b^*, C^*_{ab}, h_{ab}), and relative device data *olv** (Orange red O, Leaf green L, and Violet blue V) for the eight standard device colours of the Offset Reflective System ORS18 with the lightness L^* =18 for Black N.

Table 1: Colour names of device and elementary colours according to ISO/IEC 15775.

Achromatic colours	**Elementary colours** ***"Neither-nor"-colours***	**Device colours** ***Television (TV), Print (PR) Photography (PH)***
five achromatic colours:	*four elementary colours:*	*six device colours:*
N Black (french noir)	*R* Red *neither yellowish nor blueish*	*C* Cyan blue
D Dark grey	*G* Green *neither yellowish nor blueish*	*M* Magenta red
Z Central grey	*B* Blue *neither greenish nor reddish*	*Y* Yellow
H Light grey	*J* Yellow (french jaune) *neither greenish nor reddish*	*O* Orange red
W White		*L* Leaf green
		V Violet blue

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Table 1 includes the colour names for the device and elementary colours used in image technology according to ISO/IEC 15775. These names are also used in ISO/IEC TR 19797 for output linearization of devices and in ISO/IEC TR 24705 for the relative colorimetric input and output methods of devices. For example in these documents the relative coordinates are connected to either the device or the elementary colours and are called either *olv** or *rgb**.

2. RELATIVE COLORIMETRIC SYSTEM

The Relative Colorimetric System RCS has similar properties compared to the Natural Colour System *NCS*, see Hard and Sivik (1982). In both systems White W and Black N and the four elementary colours Red R, Yellow Y, Green G and Blue B are reference points. The relative coordinates of the RCS are scaled in relation to these reference points.

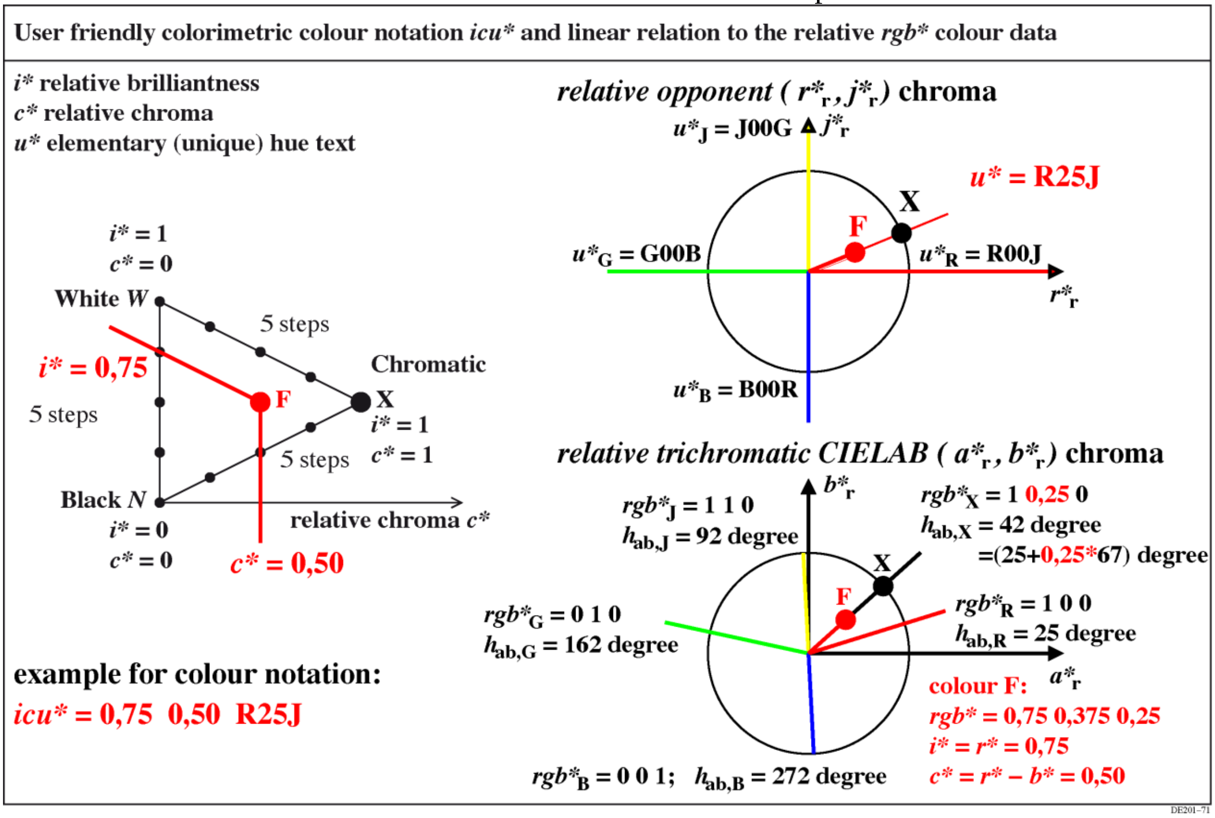

Figure 1: User friendly colour notation ***icu**** *and linear relation to relative* ***rgb**** *colour data*

Figure 1 shows as example the colour notation *icu** = (0,75, 0,50, R25J) and the calculation of the corresponding *rgb** data. For this calculation the CIELAB hue angles h_{ab} = [25, 92, 162, 272] of the four elementary hue angles of RJGB are used which are represented by the CIE-test colours no. 9 to 12 of CIE 13.3. In the elementary relative chroma diagram (r^*_r, j^*_r) the hue is shifted 25% from red R towards yellow J. The final values are rgb^*_X = (1, 0,25, 0) for the colour X and rgb^*_F = (0,75, 0,375, 0,25) for the colour F, compare figure 1.

There is not enough space here to show examples for the calculations between standard CIELAB data and relative CIELAB data in both directions. DIN E 33872-1 and a paper of Richter (2007) include the equations for the transfer in both directions. For the transfer the 8 device reference colours must be given. For eight standard device systems many figures in standard, adapted and relative CIELAB spaces are included in the file (8 pages, 3,5 MByte) http://www.ps.bam.de/De01/10L/L01e00NP.PDF

Remark: The 16 figures of the file on each page are defined by vector graphics and can be scaled by up to a factor 16, for example with the software *Adobe Reader*. The technology of this AIC publication is based on word files with figures defined in pixel format. This technology does not allow such high magnifications.

3. DIGITAL AND ANALOG COLOURS

The CIELAB data and the equivalent data *icu** (relative brilliantness, chroma and elementaryhue text) of the eight reference colours of the Offset Reference System ORS18a can be studied in Figure 2. If the colour input data *icu** = (1, 1, B00R) and the equivalent data *rgb** = (0, 0, 1) are given, then the elementary hue Blue B is produced in the output.

One advantage is that the elementary hue B is produced on any device instead of different hues between very reddish and greenish blue on different devices. For eight standard device systems the relation between their device colour hues and the elementary colour hues is shown by many figures in the file (8 pages, 3,5 Mbyte)
http://www.ps.bam.de/De10/10L/L10e00NP.PDF

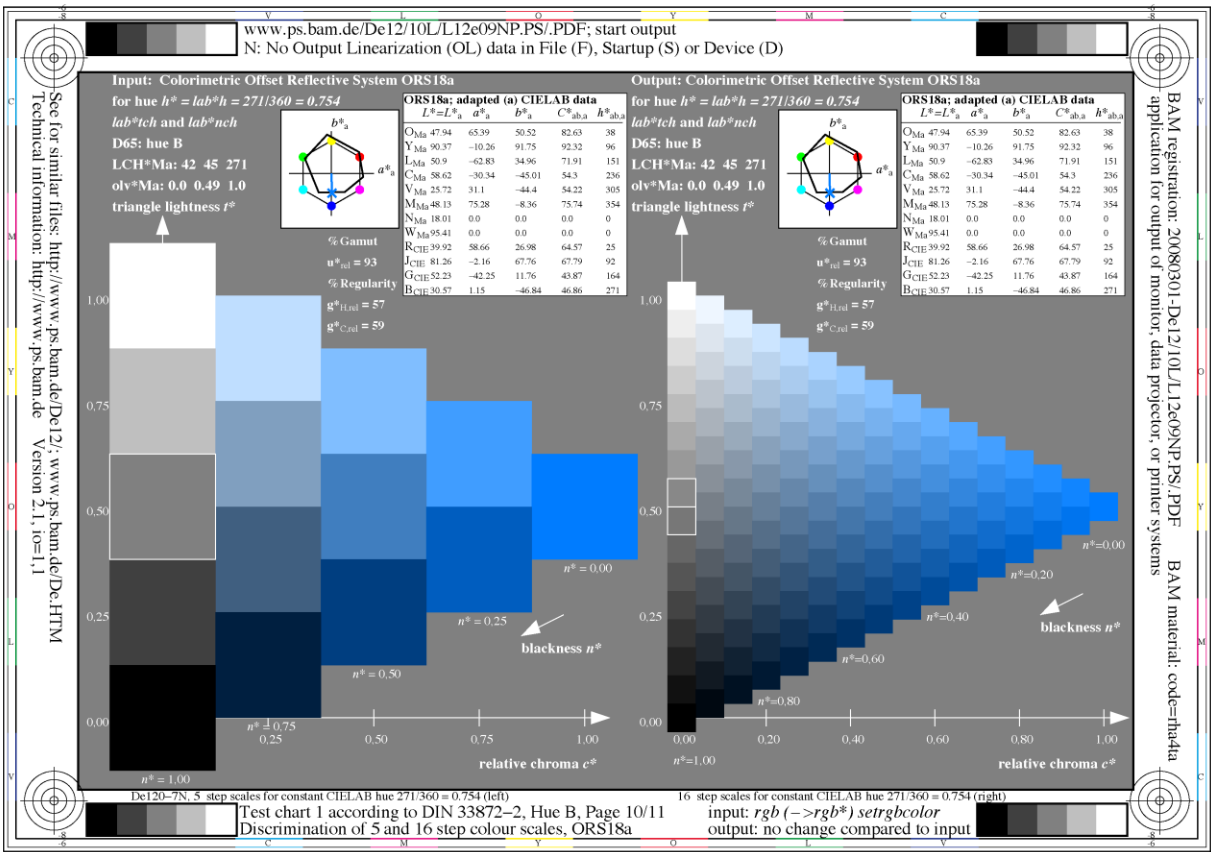

Figure 2: 5- and 16-step colour scales of the hue elementary blue

Figure 2 shows a DIN-test chart according to DIN 33872-2 with 5- and 16-step colour scales between the three anchor points Black N, White W, and Blue B. The adapted CIELAB data of the eight device colours of the Offset Reference System OSR18a are given on the top left side and the CIELAB data of the 4 elementary colours RJGB and 4 intermediate colours are given on the top right side. For larger size of figure 2, see the URL (11 pages, 364 kByte)
http://www.ps.bam.de/De12/10L/L12e00NP.PDF

According to DIN 33872-1 to -6 the relative *rgb* data of image technology can be interpreted as either device data *olv** or as elementary data *rgb**. For example the colour data set *rgb* = (0, 0, 1) produces by interpretation as *olv** data the device hue Violet blue V (h_{ab}=305 degree in CIELAB on output page 5 of the file) and by interpretation as *rgb** data the elementary hue Blue B ((h_{ab} =272 degree on output page 10 of the file).

4. ADVANTAGES OF THE RELATIVE COLORIMETRIC SYSTEM (RCS)

If a colour device manufacturer has applied a linearization method for his device system, for example according to ISO/IEC TR 19797, then there is a linear relation between *rgb* data and CIELAB data *LCH**. All *rgb* data with a linear relation to CIELAB data are called *rgb** data (with a star). This property leads to the further advantage that equally spaced input data *rgb** produce equally spaced output colours in *LCH**. If both the elementary hues are considered and an output linearization method is applied, then the relative digital coordinates *icu** are user friendly. There are many advantages, if the often undefined *rgb* data of image technology are interpreted and managed with the following two properties:

1. as elementary data according to the elementary hues of the CIE-test colours no. 9 to 12.
2. as *icu** or *rgb** data which have a linear relationship to the adapted CIELAB data.

The Offset Reflective System ORS18a is used as reference system. Most ink jet printers and copiers use inks with very similar properties compared to the offset inks. For the colour series along a line in CIELAB space between White W and the six chromatic colours OYLCVM the relative brilliance *i** is defined as equal to 1. Therefore the relative brilliantness *i** is device dependent which is different compared to the blackness *n** defined in the *NCS* system.

This device dependence of *i** has the disadvantage that the colour series between White and the six chromatic colours OYLCVM may not appear equal in relative brilliantness *i** or in relative blackness *n**. However, up to now by colorimetry there seem to be no model, which can predict the CIELAB data of the four elementary colours in the sense of the *NCS* system. Richter (2007) has published one first attempt to reach this goal by using the new CIE LMS cone sensitivities. Additionally this paper includes all the equations for the transfer between the CIELAB coordinates and the relative CIELAB coordinates in both directions, for example between *LAB**, *rgb** and *icu**. A first example of a digital – analog colour atlas based on offset printing on standard offset paper and on elementary hues will be shown as a poster.

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