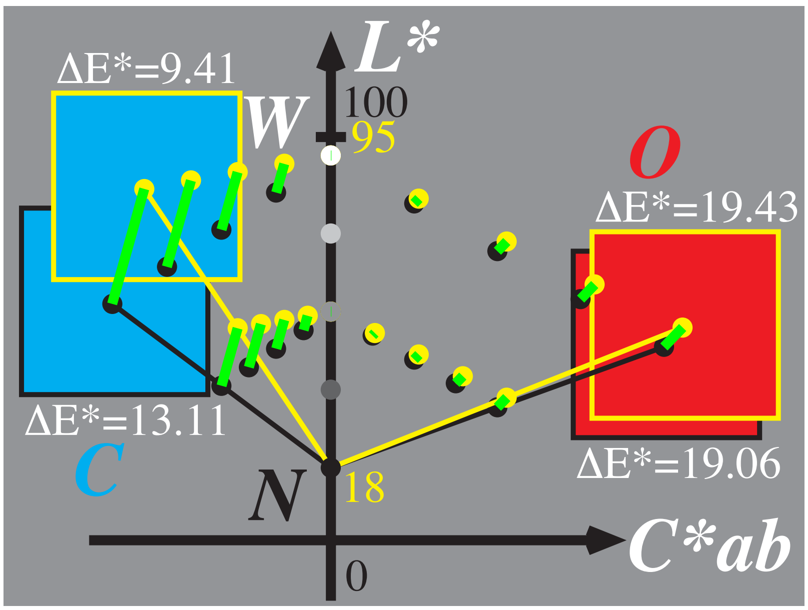
Device dependent linear relative CIELAB data *lab and colorimetric data for corresponding color input and output on monitors and printers**

Klaus Richter
Federal Institute for Materials Research and Testing (BAM)
D-12200 Berlin, Germany

An image includes a large variety of colors and shades. There are many different user requirements between *absolute* and *relative* CIELAB reproduction. The focus of this paper is a *relative* CIELAB reproduction which maintains the CIELAB hue and the *relative* CIELAB chroma and lightness in any hue plane. There is only one solution shown in Fig. 1 which includes the *absolute* and *relative* CIELAB chroma and lightness.



ME321–41, Colour management of hues O-C; TV18 <-> PR18

Fig. 1: Monitor and printer colors for complementary colors Orange red (O) and Cyan blue (C) in the CIELAB diagram *(L*, C*ab)*. The delta E* data are CIELAB color differences for the 5 step color series C–W and O–W of the standard monitor and printer.

In Fig. 1 the 5 step color scales C–W and O–W are equally spaced in CIELAB and shown as yellow and black balls at the surface and inside the color gamut. A *linear* relation between the *relative* digital coordinates, for example *rgb* in the file and the measured *absolute* CIELAB chroma and lightness in the CIELAB diagram *(L*, C*ab)* is a basic user requirement. After device linearization for example according to ISO/IEC TR 19797:2004 this is fulfilled and this is the setup_state for an efficient output on monitors or printers. Further for an efficient recognition of the color output the available maximum color gamut of the monitor and printer should be used.

In this paper instead of the color data *rgb* the colorimetric data *rgb** (star coordinates) are used which have a linear relationship to *L** and *C*ab*. For example in Fig. 1 for the achromatic series N–W the three *rgb** data (0.5, 0.5, 0.5) produce the intermediate CIELAB lightness *L** =56.7 = (95.5–18)/2 between black N and white W. Similar for the cyan series C–W the *rgb** data (0.5, 1, 1) produce the intermediate color between C and W. If instead of the color data *rgb* the colorimetric data *rgb** are used then there is a linear relationship to *L** and *C**ab. As a result there is a well defined connection between the colorimetric data *rgb** and the CIELAB data for any color for example for 5x5x5 colors, a table *rgb* – *L*a*b** is produced by measurement and a table *rgb** – *L*a*b** can be calculated. If the device is linearized this table is identical. Otherwise for the same *L*a*b** data a mapping between *rgb** and *rgb* solves the user requirement to produce a linear relation for the *rgb** input data and the CIELAB output.

Many examples and application for an equally spaced input on scanners and an equally spaced output on monitors and printers are given in ISO/IEC TR 24705:2005. From different sources digital ISO/IEC-test charts are available with 16 step color scales which are equally spaced in *rgb** and analog ISO/IEC-test charts with *L*a*b** measurement data for CIE standard illuminant D65, 2 degree, and the 45/0 geometry.

According to Fig. 1 the output on monitors and printers will produce the same CIELAB hue and the same *relative* CIELAB chroma and lightness. If the luminance and the chromaticity of the white point on the monitor and the printer is the same, then the same *relative* **color appearance** is produced. In Fig. 1 the two CIELAB colors on the monitor and the printer of the same hue are called **corresponding colors**.

For a better understanding some more information about the different *rgb* data is added. In image technology there are color and colorimetric data *rgb*. Colorimetric data have a relationship to CIELAB by simple equations, for example the *rgb* data of the color spaces sRGB (IEC 61966-2-1) and Adobe RGB (www.adobe.com). The colorimetric data *rgb** of this paper have additionally a *linear* relationship to CIELAB.

Device	rbg data	Relation to CIELAB
TV	*rgb* TLS18, not linearized	nonlinear and complex (e.g. tables 9x9x9)
TV	*rgb* sRGB (IEC 61966-2-1)	nonlinear and simple equations
TV	*rgb* Adobe RGB (www.adobe.com)	nonlinear and simple equations
TV	*rgb** TLS18, linearized	linear and simple equations
PR	*rgb* ORS18, not linearized	nonlinear and complex (e.g. tables 9x9x9)
PR	*rgb** ORS18, linearized	linear and simple equations

Table 1: rgb data and relation to CIELAB for monitor (TV) and printer (PR)

According to Fig. 1 the *L** and *C*ab* data of Cyan on the monitor and the printer are different. Therefore for both devices the colorimetric data *rgb* in the sRGB or Adobe RGB color space are different. But for the monitor and printer the colorimetric data *rgb** are equal for the corresponding CIELAB colors of a printer and monitor, for example *rgb** = (0,1,1), if the Cyan on the monitor and the printer has the same hue.

There are *equivalent* color data, for example the CIELAB measurement data *L*a*b** or *L*C*H**. Instead of the absolute coordinates *LAB*LCH* the relative coordinates *lab*lch* are used in image technology. Similar instead of the relative data *lab*rgb* equivalent colorimetric data *lab*cmy* (Cyan, Magenta, Yellow) or *lab*nce* (blackness, chromaticness, elementary hue) are appropriate. A relative color image technology defines the calculations, the coding and the transformations, see Richter (2005). Example ISO/IEC-test charts and device outputs will be shown at the meeting.

References

ISO/IEC TR 19797:2004-09, Device output of 16-step colour scales, output linearization method (LM) and specification of the reproduction properties

ISO/IEC TR 24705:2005-10, Method of specifying image reproduction of colour devices by digital and analog test charts

Klaus Richter, Relative Colour Image Technology (RCIT) and RLAB lab* (2005) Colour Image Encoding, see the URL (73 pages, 900 kByte) http://www.ps.bam.de/RLABE05.PDF