Correcting Tristimulus Colorimeters Errors

& The Four Color Matrix Method (FCMM)

ORIGINS OF COLORIMETRY

The human eye has three types of color sensors known as red, green and blue cone cells which work together through the brain to give the perception of all colors. In the late 1920s William Wright and John Guild performed meticulous testing with groups of healthy young adults to determine the spectral responses of these three types of cone cells. In 1931 the C.I.E. (International Committee on Illumination) adopted these data as the CIE color-matching functions and defined the CIE 1931 XYZ color space. This work was so well performed that results remain essentially unchanged to the present day. Changes include interpolation of the original five nanometer data to one nanometer, and the addition of responses to low level illumination.

WHAT A TRISTIMULUS COLORIMETER SHOULD DO

The goal of any tristimulus colorimeter is to measure a light source or display with responses matching the three CIE color-matching functions [$\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$]. In order to do this the colorimeter typically employs some form of filter/detector combination. These may have either a single detector with sequentially applied filters or multiple detectors with filters. Filtering detector response to match the CIE color-matching functions is difficult. In fact, most commercial tristimulus colorimeters, including two dimensional colorimeters, have significant detector/filter f1' errors. Measurement results can be reasonably accurate when the colors are broadband as those derived from pigments and dyes (i.e., paints, fabrics or incandescent displays) because colorimeters are typically calibrated against **NIST** (*National Institute of Standards and Technology*) traceable CIE Illuminant A or 3000° K tungsten-halogen working standards, however the three primary colors (red, green, blue) that comprise the color gamut of LCD or LED displays are usually other than broadband. Hence, significant errors may be encountered when measuring the primary colors of a display, or any mix of them.

CORRECTION METHODS

The demand for accuracy of display colors requires improvement in accuracy in the instruments used to measure them. Some means must be used to correlate true chromaticity coordinates (x,y) of the primaries of the display to be measured with those as measured by the colorimeter. The true, or reference coordinates can be determined by measuring the display primaries with a calibrated reference spectroradiometer. The colorimeter to be calibrated measures the display primaries to determine the measured coordinates. The **ASTM** (*American Society of Testing and Materials*) has recommended matrix methods for correlating colorimeter measurements with reference measurements. The ASTM matrix methods improve the accuracy of the colorimeter, but they are subject to errors due to dependence on measured luminance as well as chromaticity. Errors in luminance are reflected as errors in chromaticity. ***Colorimetry Research, Inc.*** has chosen to use a better matrix method developed by Ohno and Hardis at NIST, "***Four Color Matrix Method for Correction of Tristimulus Colorimeter***". This FCMM uses only the reference and measured chromaticity coordinates of the three primaries and white, a blend of the three primaries. Therefore, corrected chromaticities are free of errors in luminance measurement. The same matrix solution provides corrected chromaticities for any color within the gamut of the display primaries. The FCMM has proven to be a significant improvement over previous matrix methods. However, there are still residual errors in measuring points within the display gamut which are distant from the primaries and white. These depend upon how close the detector/filter combinations are to their respective CIE color-matching functions. ***Colorimetry Research, Inc.*** uses proprietary new-technology filters and coupling optics to reduce typical 3% to 8% f1' errors to between 1% and 3%. Thus, ***Colorimetry Research, Inc.*** colorimeters are able to attain high chromaticity accuracy over the entire display gamut.

(1) The CIE f1' error is a recommended measure of the difference in response between a detector/filter combination and the intended filter response function.

COLORIMETRY
RESEARCH, INC
www.colorimetryresearch.com

Get in touch

Sales: sales@colorimetryresearch.com
Engineering: engineering@colorimetryresearch.com
Support: support@colorimetryresearch.com