Color Management Terms

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Calibration

Calibration is the process of making a particular device such as a monitor, scanner or printer conform to a known standard. In monitor calibration, the brightness and contrast of the monitor are set for optimum dynamic range, and the gamma curves and white point are adjusted to a standard values. For the most accurate results, calibration should be performed using an instrument such as a colorimeter or spectrophotometer that measures light and color combined with software designed to adjust the characteristics of the device.

Characterization

Characterizing a device means measuring, recording and encoding the way it reproduces color. To make this data accessible to the color management system, it is normally written out as an ICC color profile.

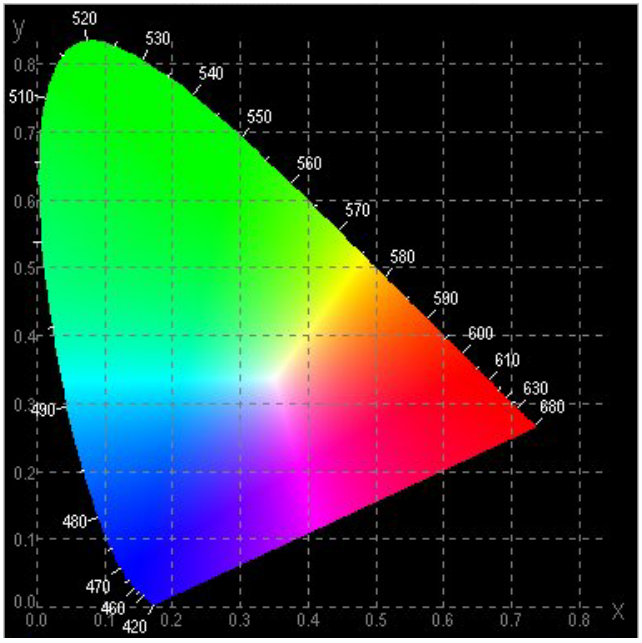
Chroma (or Chromaticity)

Chroma is a name that applies to the hue and saturation part of a color or color image, without regard to its brightness. Neutral gray colors have no chroma while

intense colors have lots of chroma. The brightness component of a color or color image is called luminance.

Chromaticity Coordinates

This term refers to the values of hue and saturation for a specific color, often defined in terms of standard (x,y) coordinates based on the CIE XYZ color space. A graph of the x-y plane is sometimes called a *CIE chromaticity diagram*.



In the above diagram, the colors of the spectrum are found around the edges and are labeled by their wavelength in nanometers.

CIE

CIE is an abbreviation for *Commission Internationale de l'Eclairage*—an international organization that develops color standards widely used in the industry.

CIE XYZ

This color space defines so-called XYZ tristiumulus values which approximate and quantify the response of the human visual system to light of different colors. The XYZ coordinates of a color are derived from a series of measurements at different wavelengths which are then correlated to predefined *color matching functions*. While there are limits to using XYZ to define color, this widely accepted color model developed in the 1930s forms the basis of most modern spaces.

CIE Lab

The CIE Lab color space is a mathematical variation of the CIE XYZ color space that represents colors by two logically different components:

L which defines the perceived brightness of the color

ab which, taken together, define the hue and saturation of the color using the 2-dimensional a-b plane.

This is one of the most popular standard color spaces in use today.

CIE Standard Illuminants

Since colored objects or prints look different in different light, the CIE has defined a number of standard lighting conditions called illuminants. The spectral response of these illuminants is defined for each of a set of narrow wavelength bands that span the visible spectrum. Although these ideal illuminants are critical to color management, most can only be approximated in the real world. Some of the standard illuminants and their corresponding CIE xy chromaticity coordinates as defined in the CIE 1931 standard are:

		CIE	
Name	**Description**	**x**	**y**
A	2854K Incandescent Light	0.4476	0.4075
B	4874K Direct Sunlight	0.3840	0.3516
C	6774K Indirect Sunlight	0.3101	0.3162
D50	5000K Bright Incandescent Light	0.3457	0.3586
D65	6504K Natural Daylight	0.3127	0.3297t
E	5500K Normalized Reference	0.3333	0.3333

Standard Observer

In order to match the response of the human eye, the CIE has defined two commonly used standard observers—2º and 10º. This difference results for the fact that color vision is more acute in the central part of the visual field (represented as a cone centered on the eye with an angular radius of 2º) than in the surrounding area.

CCD (Charge Coupled Device)

CCD stands for Charge Coupled Device. CCDs are the photosensitive elements used by most scanners and digital cameras to capture images.

CMM (Color Matching Method)

This term is a synonym for *Color Engine* (see below).

Color Engine

Different color engines represent generally proprietary software systems for translating colors or color images from one color space to another. The Microsoft ICM 2.0 color engine has been incorporated in versions of Windows since Windows 98 and versions of Windows NT since Windows 2000. Apple (ColorSync), Adobe and Kodak (KCMS), among others, also have their own proprietary color engines.

Color Management

Color Management is the name given to processes and technologies whose purpose is to maintain the consistent color appearance of objects and images as they are reproduced using a variety of different devices such as scanners, monitors and printers.

Color Profile

A color profile or ICC color profile is a file designed to be used with a specific device under prescribed conditions. This file describes how the device reproduces input colors for the conditions under which the profile was created. For details of the ICC color profile format, see http://www.color.org. There are three types of color profiles:

1. Monitor or Color Space Profiles

Monitor profiles simply define a set or RGB primary colors, a white point, and a set of gamma curves. This information is sufficient to define the characteristics of a monitor or an RGB color space.

2. Scanner Profiles

   Scanner profiles contain tables that describe how a scanner translates the colors it sees to RGB (or sometimes CMYK) values.

3. Printer Profiles

   Printer profiles contain tables that describe how a printer translates the RGB (or sometimes CMYK) colors it receives as input to output colors. A printer profile is only valid for a specific combination of inks, paper, and viewing conditions.

Color Rendering Index (CRI)

The color rendering index is a numerical rating of how well a light source matches a specific standard—a perfect match has a CRI of 100. The CRI is computed by measuring the colors of eight sample patches and comparing the readings to those you would expect if the lighting was a perfect match with some standard illuminant. The CRI is commonly used to rate fluorescent bulbs used in commercial viewing booths.

Color Space

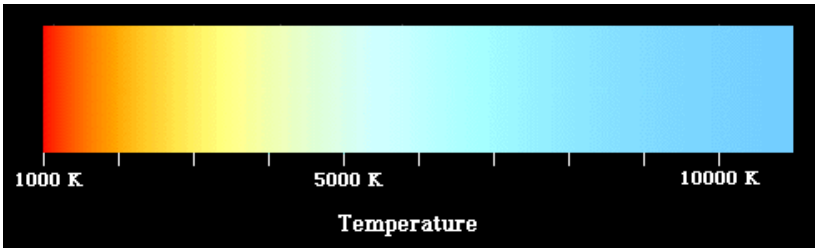
A color space is simply the set of all the colors that can be represented using a given color coordinate system.

ColorSync

Apple's color engine.

Color Temperature

Color temperature is a color scale based on the color emitted by objects when they are heated. When a piece of metal gets hot enough, it glows red; when heated further it first turns yellow, then white and finally blue (see figure below). Color temperature is commonly used to characterize light sources. Full sunlight at noon has a color temperature around 5500°K.



Colorant

A colorant is a material capable of reproducing color. Dyes are water-soluble colorants; pigments are insoluble colorants. While dyes tend to be available in a wider range of colors, most truly light fast colorants are pigments. The phosphors in a monitor or the liquid crystals in an LCD panel are also colorants.

Colorimeter

A colorimeter is a device that measures the red, green and blue components of colored light using a set of three specially designed color filters whose response is designed to mimic that of the human eye.

D50

D50 is a CIE Standard Illuminant designed to match daylight with a color temperature of 5000°K. D50 is the standard for graphic arts and pre press industries.

D65

D65 is a CIE Standard Illuminant designed to match daylight with a color temperature of 6500°K. D65 is the standard used in sRGB and tends to work better for CRT monitors than D50 which is a little more yellow.

Delta-E

Delta-E (also written as ΔE) is a unit of color difference. One ΔE is equal to the smallest change in color the human eye can detect.

Densitometer

A densitometer is an instrument that measures *optical density.* A transmission densitometer measures the amount of light passing through a piece of film; a reflection densitometer measures the amount of light reflected by an printed image.

Density

See *Optical Density.*

Device-Dependent Color

Color based on the characteristics of a specific device is called device-dependent. Examples of device-dependent color are: an RGB image whose appearance has been tuned for an uncalibrated monitor or a CMYK image created for a specific printing press, paper stock and ink set.

Device-Independent Color

Color defined in terms of a known color space standard is said to be device-independent since its appearance is not tied to the characteristics of any particular device.

dMax

The dMax value of a film, scanner or printer describes the darkest black it can reproduce, measured as an optical density. For a film transparency, dMax refers to the optical density of unexposed film, after development. For a scanner, dMax refers to the darkest shadow detail it can resolve, although there are no real standards for how this is measured. For a printer, dMax refers to the optical density of the darkest black it can output.

dMin

The dMin value of a film, scanner or printer describes the brightest white it can reproduce, measured as an optical density. For a film transparency, dMin refers to the optical density of the clear film base. For a printer, dMin refers to the optical density of the paper stock.

Dynamic Range

When applied to color devices, dynamic range refers to the spread between the lightest and darkest brightness levels the device can reproduce. When applied to images, dynamic range refers to the spread between the lightest and darkest parts of the image. The range of density that a film stock, digital camera, scanner, or measuring instrument can detect, from the lowest to the highest, usually expressed in O.D. (Optical Density) units. The lowest density is termed dMin, the highest density is termed dMax.

Gamut

A gamut or color gamut is the full range of colors that a given device or color space can reproduce.

Gamut Compression

When colors are translated from a wide-gamut color space to one with a more limited color gamut, gamut compression is used to bring the out-of-gamut input colors into the output color gamut. This can result in a loss of color information or color shifts.

ICC

ICC stands for International Color Consortium—a collaborative effort by a group of companies to define and disseminate standards for color profiles.

ICM (Image Color Matching)

ICM is the name of the Windows color engine.

Illuminant

An illuminant is a light source.

Kelvin

Degrees Kelvin are a measure of temperature similar to degrees Centigrade, but offset so that 0 degrees corresponds to a temperature of absolute zero (approximately minus 273°C).

Metamer

Two colors that look identical under one type of illumination and different under another all call metamers. This difference is caused two factors: the different spectral properties of the illuminants and the fact that the eye works by deriving red, green and blue as weighted averages of light of different wavelengths.

Nanometer

A nanometer is a unit of length equal to one-millionth of a millimeter. Wavelengths of visible light are typically measured in nanometers.

Optical Density

Optical Density (sometimes just referred to as Density) is a measure of how much light passes through a piece of film (Transmission Density) or how much light is reflected from the surface of a page or object (Reflection Density). Density is computed as minus the $\log_{10}$ of the fraction of light transmitted or reflected. For example, a neutral gray paint chip that reflects 50% of the light that hits it has an optical density of:

$$-\log_{10}(0.50) = 0.301$$

Higher densities correspond to darker film or ink while lower densities correspond to lighter film or prints. A typical maximum slide film density is around 4.0; a typical maximum print density is about 2.3.

Phosphor

A phosphor is a chemical compound that emits light when bombarded by a stream of electrons. The phosphors on the inside of the face of the CRT (cathode ray tube) in your monitor are what produces the image when struck by a modulated beam of

electrons that sweeps across the screen in a series of scan lines. Most CRTs use a standard set of red, green and blue phosphors called P22—the sRGB color space is based on the primary colors produced by P22 phosphors.

PMT (Photomultiplier Tube)

A photomultiplier is a vacuum tube that generates an output signal that depends on the amount of light it receives. Photomultipliers are used as the light sensing elements in most drum scanners—they excel at extracting shadow detail from very dense transparencies.

Primary Colors

Primary colors are those colors from which all other colors can be derived by mixing the primaries in different amounts. For a CRT monitor, the primary colors are the pure red, green and blue colors produced by the phosphors embedded in the inner surface of the face of the CRT. For a printer or printing press, the primary colors are the colors of the inks.

Profile

See *Color Profile*.

Rendering Intent

The ICC has defined four rendering intents. These rendering intents instruct the color engine in the color management system what strategy to use when attempting to convert an image from one color space to another. The rendering intent is concerned primarily with the processing of so-called out-of-gamut colors—colors that have an exact representation in one color space but not in the other. The four rendering intents are:

1. Absolute Colorimetric.

   This intent preserves all colors that are within the gamuts of both the input and the output color space. Colors in the input color space that are outside of the output color space gamut are converted to the nearest in-gamut color, without regard to preserving brightness or saturation.
2. Relative Colorimetric.

This intent is similar to Absolute Colorimetric with the exception that the white point of the input color space is translated to the white point of the output color space.

3. Perceptual.

   Perceptual rendering compresses the entire input color space to make it fit in the output color space. It does this by applying most of the compression to the most saturated colors while leaving less saturated colors (that are likely to fall within both the input and output color gamuts) largely unchanged. While the method is less accurate in some sense than Absolute or Relative Colorimetric, Perceptual is often the best rendering intent to use for photographic images as it avoids abrupt color changes and makes full use of the available output colors.

4. Saturation.

   Saturation rendering preserves saturation when translating from one color space to another, at the possible expense of hue and brightness. This rendering intent is designed for charts, maps and other business graphics or illustrations that use solid color to identify different visual elements.

Spectral Data

The spectrum of visible light emitted by a light source, transmitted through a piece of film, or reflected from an object can be divided into narrow bands. Tabulated measurements of the amount of light in each of these bands (typically 10 or 20 nanometers wide) is called *spectral data*. This is the most comprehensive way to measure color. Spectral data is measured using a *spectrophotometer.*

Spectrophotometer

A spectrophotometer is an instrument that measures colored light by dividing it up into a series of narrow spectral bands and measuring how much light falls into each band. This is the most accurate (and usually the most expensive) type of color measuring instrument you can buy.

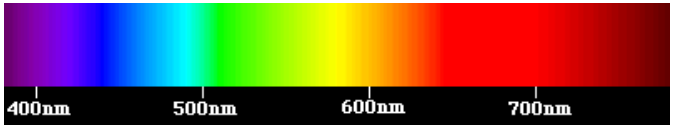
The advantage of a spectrophotometer over a colorimeter is that it can distinguish metamers—two colors that look the same under one type of illumination but different under another.

sRGB

sRGB is a standard color space created and endorsed by a consortium of industry leaders. sRGB is designed to be a good overall fit with CRT displays. It has a gamma of 2.2, a D65 white point, and RGB primaries that closely match those of the standard P22 phosphor set used by most CRTs. sRGB is the default color space for Windows and is also a good choice for publishing images on the web.

Visible Spectrum

Electromagnetic radiation in a range of wavelengths between roughly 380 and 720 nanometers is what we call visible light. The shorter, higher energy wavelengths are visible as violet or purple. As the wavelength increases, the perceived color passes through the colors of the spectrum through purple, blue, cyan, green, yellow, orange and finally red. Invisible radiation with wavelengths just shorter than visible light is called ultraviolet; wavelengths just longer than visible light are called infrared.



White Point

The white point is lightest possible color a device can produce. For a CRT, this is the color produced when red, green and blue are combined in the maximum possible amounts. When viewing reflective materials (such as prints), the white point is the color of the illuminant as reflected by the paper. White points are often defined in terms of a color temperature or, more accurately, in chromaticity coordinates.