sRGB

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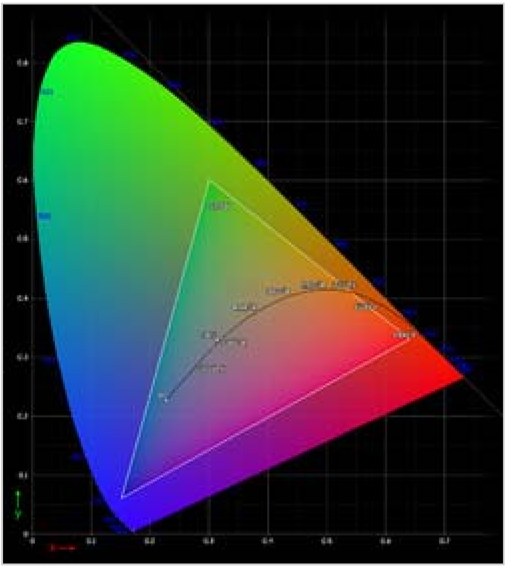
sRGB is a standard RGB color space created cooperatively by HP and Microsoft in 1996 for use on monitors, printers, and the Internet.

sRGB uses the ITU-R BT.709-5 primaries, the same as are used in studio monitors and HDTV,[1] and a transfer function (gamma curve) typical of CRTs. This specification allowed sRGB to be directly displayed on typical CRT monitors of the time, a factor which greatly aided its acceptance.

Unlike most other RGB color spaces, the sRGB gamma cannot be expressed as a single numerical value. The overall gamma is approximately 2.2, consisting of a linear (gamma 1.0) section near black, and a non-linear section elsewhere involving a 2.4 exponent and a gamma (slope of log output versus log input) changing from 1.0 through about 2.3.



CIE 1931 xy chromaticity diagram showing the gamut of the sRGB color space and location of the primaries. The D65 white point is shown in the center. The Planckian locus is shown with color temperatures labeled in degrees Kelvin. The outer curved boundary is the spectral (or monochromatic) locus, with wavelengths shown in nanometers (labeled in blue). Note that the colors in this displayed file are being specified using sRGB. Areas outside the triangle cannot be accurately colored because they are out of the gamut of sRGB therefore they have been interpreted. Also note how the D65 label is not an ideal 6500° Kelvin blackbody because it is based on atmospheric filtered daylight.

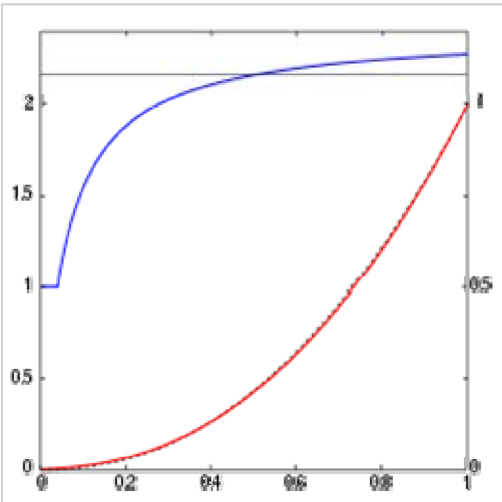
Contents

Background

The sRGB color space has been endorsed by the W3C, Exif, Intel, Pantone, Corel, and many other industry players; it is used in proprietary and open graphics file formats, such as SVG.

The sRGB color space is well specified and is designed to match typical home and office viewing conditions, rather than the darker environment typically used for commercial color matching.

Nearly all software was and is designed with the



Plot of the sRGB intensities versus sRGB numerical values (red), and this function's assumption that an 8-bit-per-channel image file placed unchanged onto an 8-bit-per-channel display will appear much as the sRGB specification dictates. LCDs, digital cameras, printers, and scanners all follow the sRGB standard. Devices which do not naturally follow sRGB (as was the case for older CRT monitors) include compensating circuitry or software so that, in the end, they also obey this standard. For this reason, one can generally assume, in the absence of embedded profiles or any other information, that any 8-bit-per-channel image file or any 8-bit-per-channel image API or device interface can be treated as being in the sRGB color space. When an RGB color space with a larger gamut is needed, color management usually must be employed to map image data to appear correctly on the display.

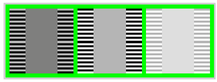
slope in log-log space (blue) which is the effective gamma at each point. Below a compressed value of 0.04045 or a linear intensity of 0.00313, the curve is linear so the gamma is 1. Behind the red curve is a dashed black curve showing an exact gamma = 2.2 power law.

The sRGB gamut

sRGB defines the chromaticities of the red, green, and blue primaries, the colors where one of the three channels is nonzero and the other two are zero. The gamut of chromaticities that can be represented in sRGB is the color triangle defined by these primaries. As with any RGB color space, for non-negative values of R, G, and B it is not possible to represent colors outside this triangle, which is well inside the range of colors visible to a human.

Chromaticity	Red	Green	Blue	White point
x	0.6400	0.3000	0.1500	0.3127
y	0.3300	0.6000	0.0600	0.3290
z	0.0300	0.1000	0.7900	0.3583

sRGB also defines a nonlinear transformation between the intensity of these primaries and the actual number stored. The curve is similar to the gamma response of a CRT display. It is more important to replicate this curve than the primaries to get correct display of an sRGB image. This nonlinear conversion means that sRGB is a reasonably efficient use of the values in an integer-based image file to display human-discernible light levels.



On an sRGB display, each solid bar should look as bright as the surrounding striped dither.

sRGB is sometimes avoided by high-end print publishing professionals because its color gamut is not big enough, especially in the blue-green colors, to include all the colors that can be reproduced in CMYK printing.

Specification of the transformation

The forward transformation (CIE xyY or CIE XYZ to sRGB)

The first step in the calculation of sRGB tristimulus values from the CIE XYZ tristimulus values is a linear transformation, which may be carried out by a matrix multiplication.[2] Note that these linear values are *not* the final result.

$$\begin{bmatrix} R_{\mathrm{linear}} \\ G_{\mathrm{linear}} \\ B_{\mathrm{linear}} \end{bmatrix} = \begin{bmatrix} 3.2410 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

Note also, that if the CIE xyY color space values are given (where x, y are the chromaticity coordinates and Y is the luminance), they must first be transformed to CIE XYZ tristimulus values by:

$$X = Yx/y,$$
$$Z = Y(1 - x - y)/y$$

The intermediate parameters R_linear, G_linear and B_linear for in-gamut colors are defined to be in the range [0,1], which means that the initial *X*, *Y*, and *Z* values need to be similarly scaled (if you start with XYZ values going to 100 or so, divide them by 100 first, or apply the matrix and then scale by a constant factor to the [0,1] range). The linear RGB values are usually clipped to that range, with display white represented as (1,1,1); the corresponding original XYZ values are such that white is D65 with unit luminance (*X*,*Y*,*Z* = 0.9505, 1.0000, 1.0890). Calculations assume the 2° standard colorimetric observer.[3]

sRGB was designed to reflect a typical real-world monitor with a gamma of 2.2, and the following formula transforms the linear values into sRGB. Let C_linear be R_linear, G_linear, or B_linear, and C_srgb be R_srgb,G_srgb or B_srgb:

$$C_\mathrm{srgb} = \begin{cases} 12.92 C_\mathrm{linear}, & C_\mathrm{linear} \le 0.0031308 \\ (1+a) C_\mathrm{linear}^{1/2.4} - a, & C_\mathrm{linear} > 0.0031308 \end{cases}$$

- where $a = 0.055$

These gamma corrected values are in the range 0 to 1. If values in the range 0 to 255 are required, e.g. for video display or 8-bit graphics, the usual technique is to multiply by 255 and round to an integer.

The reverse transformation

Again the sRGB component values R_srgb, G_srgb, B_srgb are in the range 0 to 1. (A range of 0 to 255 can simply be divided by 255).

$$C_\mathrm{linear} = \begin{cases} \frac{C_\mathrm{srgb}}{12.92}, & C_\mathrm{srgb} \le 0.04045 \\ \left(\frac{C_\mathrm{srgb}+a}{1+a}\right)^{2.4}, & C_\mathrm{srgb} > 0.04045 \end{cases}$$

(where C is R, G, or B). Followed by a matrix multiplication of the linear values to get XYZ:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.4124 & 0.3576 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9505 \end{bmatrix} \begin{bmatrix} R_\mathrm{linear} \\ G_\mathrm{linear} \\ B_\mathrm{linear} \end{bmatrix}$$

Theory of the transformation

The transformation was designed to approximate a gamma of about 2.2, but with a linear portion near zero to avoid having an infinite slope at $K = 0$, which can cause numerical problems. The condition that $g(K)$ match at some K_0 is

$$\left(\frac{K_0 + a}{1 + a}\right)^\gamma = \frac{K_0}{\phi}$$

Solving with $\gamma = 2.4$ and the standard value $\phi = 12.92$ yields two solutions, $K_0 \approx 0.0381548$ or $K_0 \approx 0.0404482$. The IEC 61966-2-1 standard uses the rounded value $K_0 = 0.04045$. However, if we impose the condition that the slope match as well then we must have

$$\gamma\left(\frac{K_0 + a}{1 + a}\right)^{\gamma-1}\left(\frac{1}{1 + a}\right) = \frac{1}{\phi}.$$

We now have two equations. If we take the two unknowns to be K_0 and ϕ then we can solve to give

$$K_0 = \frac{\alpha}{\gamma - 1}, \quad \phi = \frac{(1+\alpha)^\gamma(\gamma-1)^{\gamma-1}}{(\alpha^{\gamma-1})(\gamma^\gamma)}$$

Substituting $\alpha = 0.055$ and $\gamma = 2.4$ gives $K_0 \approx 0.0392857$ and $\phi \approx 12.9232102$, with the corresponding linear-domain threshold at $K_0 / \phi \approx 0.00303993$. These values, rounded to $K_0 = 0.03928$, $\phi = 12.92321$, and $K_0 / \phi = 0.00304$, are sometimes used to describe sRGB conversion.[4] Publications by sRGB's creators[2] rounded to $K_0 = 0.03928$ and $\phi = 12.92$, resulting in a small discontinuity in the curve. Some authors adopted these values in spite of the discontinuity.[5] For the standard, the rounded value $\phi = 12.92$ was kept and the K_0 value was recomputed to make the resulting curve continuous, as described above, resulting in a slope discontinuity from 12.92 below the intersection to 12.70 above.

Viewing environment

Parameter	Value
Luminance level	80 cd/m^2
Illuminant white point	x = 0.3127, y = 0.3291 (D65)
Image surround reflectance	20% (~medium gray)
Encoding ambient illuminance level	64 lux
Encoding ambient white point	x = 0.3457, y = 0.3585 (D50)
Encoding viewing flare	1.0%
Typical ambient illuminance level	200 lux
Typical ambient white point	x = 0.3457, y = 0.3585 (D50)
Typical viewing flare	5.0%

The sRGB specification assumes a dimly-lit encoding (creation) environment with an ambient correlated color temperature (CCT) of 5000K. It is interesting to note that this differs from the CCT of the illuminant (D65). Using D50 for both would have made the white point of most photographic paper appear excessively blue.[6] The other parameters, such as the luminance level, are representative of a typical CRT monitor.

For optimal results, the ICC recommends using the encoding viewing environment (i.e., dim, diffuse lighting) rather than the less-stringent typical viewing environment.[3]

Usage

As the recommended color space for the Internet, sRGB should be used for editing and saving all images intended for publication to the WWW. Images intended for professional printing via a fully color-managed workflow, e.g. prepress output, sometimes use another color space such as Adobe RGB (1998), which allows for a wider gamut.

Images intended for the Internet and created in one of the other color spaces may be converted to sRGB when editing, using a suitable editing program, e.g. Paint Shop Pro or Adobe Photoshop; ideally, the original non-sRGB file should be saved and the conversion to sRGB done on a copy, as some loss of image information occurs when converting to another color space.

Due to the standardization of sRGB on the Internet, on computers, and on printers, many low- to medium-end consumer digital cameras and scanners use sRGB as the default (or only available) working color space. Used in conjunction with an inkjet printer, an sRGB image produces what is often regarded as satisfactory for home use. However, consumer-level camera LCDs are typically uncalibrated, meaning that even though the image is being labelled as sRGB, one can't conclude that the image is color-accurate on the LCD.

The two dominant programming interfaces for 3D graphics, OpenGL and Direct3D, have both incorporated support for the nonlinear color space with sRGB gamma curve. OpenGL supports the textures with sRGB-encoded color components (first introduced with EXT_texture_sRGB extension, added to the core in OpenGL 2.1) and rendering into sRGB-encoded framebuffers (first introduced with EXT_framebuffer_sRGB extension, added to the core in OpenGL 3.0). Direct3D supports sRGB textures and rendering into sRGB surfaces starting with DirectX 9.

References

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Standards

- IEC 61966-2-1:1999 is the official specification of sRGB. It provides viewing environment, encoding, and colorimetric details.
- Amendment A1:2003 to IEC 61966-2-1:1999 describes an analogous sYCC encoding for YCbCr color spaces, an extended-gamut RGB encoding, and a CIELAB transformation.
- The fourth working draft of IEC 61966-2-1 is available online, but is not the complete standard.

See also

- scRGB
- Adobe RGB

External links

- International Color Consortium
- Archive copy of http://www.srgb.com, now unavailable, containing much information on the design, principles and use of sRGB
- A Standard Default Color Space for the Internet - sRGB
- OpenGL extension for sRGB textures

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