6

Colorimetric Color Spaces

In any application that requires precise, reproducible, and device-independent presentation of colors, the use of calibrated color systems is an absolute necessity. For example, color calibration is routinely used throughout the digital print work flow but also in digital film production, professional photography, image databases, etc. One may have experienced how difficult it is, for example, to render a good photograph on a color laser printer, and even the color reproduction on monitors largely depends on the particular manufacturer and computer system.

All the color spaces described in Vol. 1 [14, Sec. 8.2] somehow relate to the physical properties of some media device, such as the specific colors of the phosphor coatings inside a CRT tube or the colors of the inks used for printing. To make colors appear similar or even identical on different media modalities, we need a representation that is independent of how a particular device reproduces these colors. Color systems that describe colors in a measurable, device-independent fashion are called colorimetric or calibrated, and the field of color science is traditionally concerned with the properties and application of these color systems (see, e.g., [80] or [66] for an overview). While several colorimetric standards exist, we focus on the most widely used CIE systems in the remaining part of this section.
6.1 CIE Color Spaces

The XYZ color system, developed by the CIE (Commission Internationale d’Éclairage)\(^1\) in the 1920s and standardized in 1931, is the foundation of most colorimetric color systems that are in use today [60, p. 22].

6.1.1 CIE XYZ color space

The CIE XYZ color scheme was developed after extensive measurements of human visual perception under controlled conditions. It is based on three imaginary primary colors \(X\), \(Y\), \(Z\), which are chosen such that all visible colors can be described as a summation of positive-only components, where the \(Y\) component corresponds to the perceived lightness or luminosity of a color. All visible colors lie inside a three-dimensional cone-shaped region (Fig. 6.1 (a)), which interestingly enough does not include the primary colors themselves.

Some common color spaces, and the RGB color space in particular, conveniently relate to XYZ space by a linear coordinate transformation, as described in Sec. 6.3. Thus, as shown in Fig. 6.1 (b), the RGB color space is embedded in

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\(^1\) International Commission on Illumination (www.cie.co.at).