Handout 08 Introduction to Color Image Processing

1. Basic Concepts

(1) The colors that humans and most animals perceive in an object are determined by the nature of the light reflected from the object.

(2) Chromatic light spans the electromagnetic spectrum from approximately 400 to 700 nm; as we mentioned before human color vision is achieved through 6 to 7 million cones in each eye.

(3) A color model is a specification of a coordinate system and a subspace within that system where each color is represented by a single point.

(4) For standardization, the CIE (in 1931) designated red (700nm), green (546.1nm) and blue (435.8nm) light as three primary colors. Such a design has a biological foundation that our visions are quite sensitive to those three electromagnetic wavelengths.

(5) Having three specific primary wavelengths for the purpose of standardization does not mean these three RGB components acting alone can generate all spectrum colors.

(6) The RGB color model is based on a Cartesian coordinate system.

(7) The CMY model takes cyan, magenta, and yellow as “primary colors”; it is widely used in printing industry.

(8) Human eye distinguish one color from the other based on hue, saturation, and brightness. Hue is a color that is evoked by a single wavelength of light in the visible spectrum; saturation (purity) refers to the relative amount of white light mixed with a hue; brightness embodies the achromatic notion of intensity.

(9) For any specific color, the amounts of red, green, and blue needed to form it are called tristimulus values, and they are denoted as \(X\), \(Y\), and \(Z\).

(10) CIE chromaticity diagram is a 2D chart; any color located on the boundary of the chromaticity chart is fully saturated; any point not on the boundary but within the diagram represents some mixture of spectrum colors. The point of equal energy represents the standard white light; its saturation is zero. As a point leaves the boundary and approaches the point of equal energy, more white light is added to the color and it becomes less saturated. A straight line segment joining any two points in the diagram defines all the different color variations that can be obtained by combining these two colors additively.

(11) NTSC color system is used in analog television.

(12) YCbCr color space is extensively used in digital video.

(13) The CIE \(L^*a^*b^*\) system is based on the three dimensional coordinate system based on the opponent theory using black-white \(L^*\), red-green \(a^*\), and yellow-blue \(b^*\) components; it is perceptually uniform, which means that numerical distances can be related to human perceptual differences. It is device independent.

(14) Intensity slicing and color coding is one of the simplest ways to assign colors to a gray-scale image.
2. Related Matlab routines

cat, rgb2ntsc, ntsc2rgb, makecform, applycform

3. Matlab Programming

(1) Run the demo “Form an RGB image from three components”.
(2) Run the demo “RGB to YIQ”.
(3) Run the demo “Interactive color editor”.
(4) Run the demo “RGB to CIEL*a*b*”.
(5) In our lectures, we have mentioned that RGB color space can be converted to HSI color space and vice versa. Compose a Matlab function “rgb2hsi” to convert an RGB image to its HSI form; inversely, compose a Matlab function “hsi2rgb” to convert an HSI image to its RGB form. Verify the correctness of your programs by using a colorful image.