Light and Color

Frequency Spectrum

Spectrum describes frequency distribution of a light source

Wavelength (nm)

400 450 500 550 600 650 700

Amplitude

blue green yel. red

Johns Hopkins Department of Computer Science
Course 600.456: Rendering Techniques, Professor: Jonathan Cohen
Definitions

Hue: quality that distinguishes one color family from another (i.e. red, yellow, green, blue, etc.)

Chroma: degree of color’s departure from greyscale

Value/Lightness: quality distinguishing light from dark colors

More definitions

Achromatic light: literally light without chroma, or greyscale light

- fairly uniform frequency distribution

Monochromatic light: light which has all intensity near a single frequency
Color Mixture - Subtractive

Applies when mixing pigments and dyes

• Each substance absorbs certain frequencies
• Combining substances absorbs the union of these frequencies
• Resulting reflected light is intersection of colors reflected by each

Subtractive Mixture Example

Color Mixture - Additive

Applies to mixing of luminescent colors, such as color CRT and LCD displays, etc.

- Color refers to actual frequency spectrum of light
- Combining lights adds their frequency spectra

Additive Color Example
3 Types of retinal cones

Efficient Color Computations in Computer Graphics

Represent frequency spectrum as discrete set of samples

- Typically 3 samples: red, green, and blue
- Monitors also use samples corresponding to different phosphors
- Eye also has 3 samples (types of cones)

Does not imply that three samples for initial and intermediate produce accurate computations
Color Space Gamut

Color gamut: subspace of visible colors

No system of mixing colors from fixed number of primaries can represent all visible colors


Color Spaces - RGB cube

Shortcomings:
- perceptually non-linear
- non-intuitive for human specification


From Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, plate II.4
Color Spaces - HSV hexacone

Still not perceptually linear
Axes correspond to more intuitive perceptual qualities
- Selection similar to artist color mixing
- Choose hue of base pigment, add white, add black

Derived from projections of RGB cube

From Alan Watt, 3D Computer Graphics, 2nd edition, p. 419

HLS double hexacone

Similar to HSV hexacone
Pulls white to make the apex of upper cone
- Gives white and black similar geometric representation

L (lightness) is similar to V, but the primaries occur at L=0.5 (for HSV, V=1 for primaries)
CIE Color Space

Employs 3 artificial primaries: X, Y, Z

• Mathematical abstractions, not physically realizable

• Allow supersaturation

Larger than visible spectrum

Standard for representing colors and converting between spaces

CIE Space and Device Gamuts

from Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, plates II.1 and II.2
Gamma Correction

Exponential function converts from device-independent RGB space to device-dependent RGB

• Gamma is exponent
• Every monitor is different
• Monitor color intensities are non-linear with respect to phosphor excitation levels