


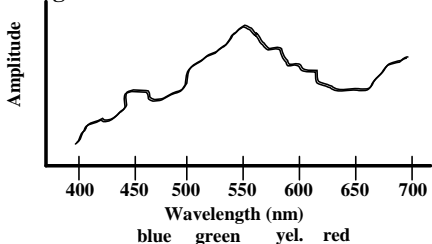
Light and Color

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




Frequency Spectrum

Spectrum describes frequency distribution of a light source



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

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




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

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




Color Mixture - Subtractive

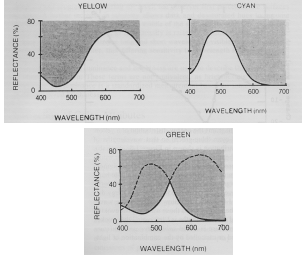
Applies when mixing pigments and dyes

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

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



Subtractive Mixture Example



from Gerald Murch, "Color Displays and Color Science", in Color and the Computer, H. John Durrett, ed., page 10.

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



Color Mixture - Additive

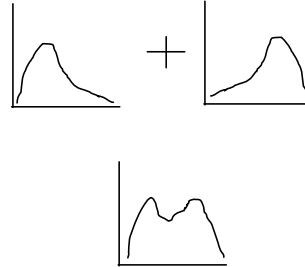
Applies to mixing of luminescent colors, such as color CRT and LCD displays, etc.

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

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



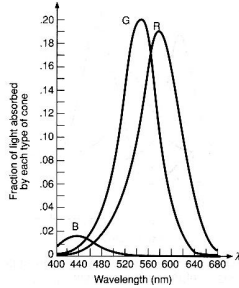
Additive Color Example



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



3 Types of retinal cones



From Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, 2nd edition, page 577

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



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

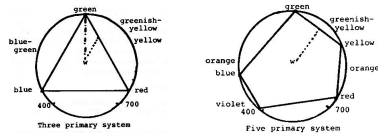
Johns Hopkins Department of Computer Science
Course 600.456: Rendering Techniques, Professor: Jonathan Cohen



Color Space Gamut

Color gamut: subspace of visible colors

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

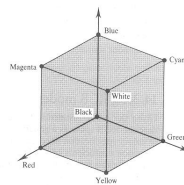


from Gerald Murch, "Color Displays and Color Science", in Color and the Computer, H. John Durrett, ed., page 13.

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



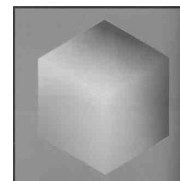
Color Spaces - RGB cube



From Alan Watt, 3D Computer Graphics, 2nd edition, p. 416

Shortcomings:

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



from Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, plate II.4

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

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

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

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)

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

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

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

CIE Space and Device Gamuts

Chromaticity Diagram

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

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

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

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

Gamma Correction Test Image

Visually test linearity of intensities

Average intensity of inner square should match intensity of outer square

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