Chromaticity Diagram
The luminance or lightness axis, when added to the chromaticity diagrams provides the third dimension for color.
Trichromatic Generalization

• Many colors can be matched by additive mixtures of suitable amounts of three fixed primary colors.

• Others have to be mixed with a suitable amount of one before it can be matched by the other two.

• All the colors can be matched in one of these two ways:
  – The restriction is that none of the primary colors can be matched by an additive mixture of the other two.
Color Gamuts

![Color Gamut Diagram](image)
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Chromaticity Diagram & Gamut (monitors)
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Nearest Color
Sharp 4 Color Display
Sharp 4 Color Display
Sharp 5 Color Display
Sharp 5 Color Display
5 Color Gamut

Color coordinates and gamut for five-primary LCDs.

Expanded color gamut reproduced by six-primary projection display
Expanded color gamut reproduced by six-primary projection display
Color Space Diagram with Various Gamuts
How do you map a color which is outside the gamut of a display with four or five primaries?

How do you map a color which is inside the gamut? Which and how many primaries do you use and why?
Color Spaces for User Interaction

- RGB Cube
- Hexacone Model
- Munsell Color System
- HSL Biconical Solid (Hue, Saturation, Lightness)
- Others
RGB Cube

- Red
- Green
- Blue
- Magenta
- Cyan
- White
- Black
- Yellow
Hexacone Model
Hexacone Model
Perceptually Uniform Color Spaces

- Chromaticity specifies the basic color (hue) of an object.
- Comparing chromaticities gives the best indicator of the color differences between two objects.
- A chromaticity diagram where equal physical distances (on the diagram) indicate equal perceptual differences would be useful.
- Why?
MacAdam Experiments

- Subjects were shown colors of known chromaticity (luminance was held constant) and were asked to match the sample using an adjustable color source.

- Each chromaticity point studied is surrounded by an ellipse proportional in size to the standard deviation of the difference between the actual and match chromaticities.

- The ellipse indicate how rapidly the color change is perceived.
Just Noticeable Differences (JND’s) MacAdam Ellipses

Note the varying size and orientation of the ellipses.
MacAdam Ellipses - Nonlinear Color Spaces (uvw)

\[
u = \frac{2x}{(6y - x + 1.5)}
\]

\[
v = \frac{3y}{(6y - x + 1.5)}
\]

Basis for the CIELUV and CIELab systems
Munsell Color System

Munsell Color System

Value

Hue

Chroma

- Red-Purple
- Red
- Yellow
- Green-Yellow
- Green
- Blue
- Purple-Blue

- 12
- 10
- 8
- 6
- 4
- 2
- 0

- 10
- 8
- 6
- 4
- 2
- 0
Munsell Color System

Billmeyer
Munsell Color System
Munsell Color System
Munsell Color System
Biconical Color Solid

George Joblove
Biconical Color Solid

George Joblove
Biconical Color Solid

George Joblove
Color Constancy

- “The eye has evolved to see the world in unchanging colors,… regardless of shifting and uneven illumination.”

- “The fact remains that objects retain their color identity under a great variety of lighting conditions.”

- Edwin Land, Scientific American 1977
The most deeply shadowed regions of the church’s white siding project luminances to the eye almost equal to the luminances projected by the black shingles is the direct sunlight. Yet they look very different.
Color Constancy
Color Constancy
End...