Color Theory

COMP575/COMP770

Today:

- Finish up Color
- Tone mapping
- Image representation

Color Theory

- CIE XYZ color space
  - 3 color matching functions: X, Y, Z
  - Y is luminance
  - X and Z are color values

xyY color space

- Since Y is luminance, it carries no color data
- Chromaticity can be carried in new parameters x and y

\[ x = \frac{X}{X + Y + Z} \]
\[ y = \frac{Y}{X + Y + Z} \]
\[ Y = Y \]
\[ X = \frac{Y}{x} \]
\[ Z = \frac{Y}{y} (1 - x - y) \]

**Color Theory**

- Gamut
  - Formed by plotting x,y colors
- Let's mix colors!

The line between two points represents all the mixes possible with those colors.

**Color Theory**

- sRGB space
Color Theory

Intuitive colors?
RGB is not necessarily intuitive with human color perception.

Color Theory

- RGB model

![RGB model](image)

Visual Computing, Nielsen et al.

Color Theory

- HSV model
  - Color wheel (hue), saturation, value

![HSV model](image)

Color Theory

- HSV model

![HSV model](image)
Today:

- Finish up Color
- **Tone mapping**
- Image representation
- Signal processing
- Sampling
- Reconstruction

**Tone mapping**

- Images
  - Stored for easy display
  - Not accurate representations
  - Most output devices show 256 brightness levels
  - Most image formats store 256 brightness levels

- Humans perceive more than 256 brightness levels
  - 4-5 log units, 100,000 : 1
  - Images are typically 2 log units, 100 : 1
- Your simulation images will have more than 256 brightness levels
  - Likely RGB float values
  - How to store them as standard images? (RGB bytes)

**Tone mapping**

- High dynamic range
  - This is normal range for humans
  - Images are *low dynamic range*
  - Must take HDR images and map them into smaller range
Tone mapping

- Clamping
  - Only keep small range (0.0 - 1.0)
  - Clamp low and high values
- Issues?

Can discard large amounts of the image, or even the entire image!

Tone mapping

- Remap values
  - Linear scaling to destination values
- Issues?

\[ n = \frac{L}{L_{\text{max}}} \]

Can remap many colors to the same value, losing detail.

Tone mapping

- Many, many more mappings...
  - Average luminance scale
    \[ n = 0.5 \cdot \frac{L}{L_{\text{avg}}} \]
    - Preserve color ratios
    - Separate reflectance and illuminance

Can remap many colors to the same value, losing detail.

Today:

- Finish up Color
- Tone mapping
- Image representation
- Signal processing
- Sampling
Image representation

- Grid of values
  - Each value is a 'pixel'
- How to store?
  - Single array with map/unmap function
  - 2d array (x,y dimensions)
  - Could be by spatial dimension
  - or channel dimension

What is a pixel?
- Little box of color?
A pixel stores a single discrete sample result. It is not necessarily the color for the area under the pixel.

**Image representation**

- Aliasing
It is impossible to tell an aliased image from an image of an object that is similar to the alias pattern.

**Image representation**

- Aliasing