

Color Theory

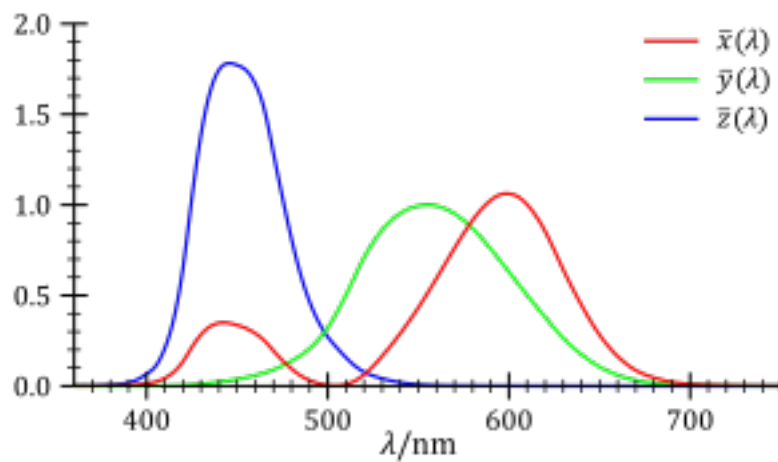
COMP575/COMP770

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



WP user acdx

Color Theory

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

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$Y = Y$$

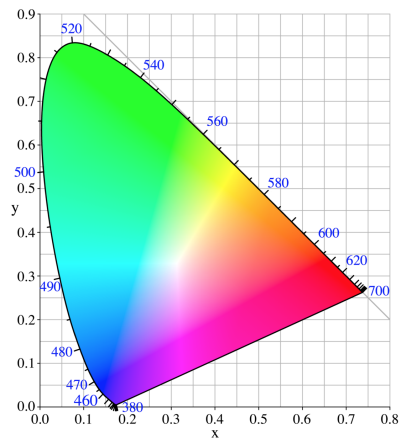
$$X = \frac{Y}{y}x$$

$$Z = \frac{Y}{y}(1 - x - y)$$

Color Theory

- Gamut
 - Formed by plotting x,y colors

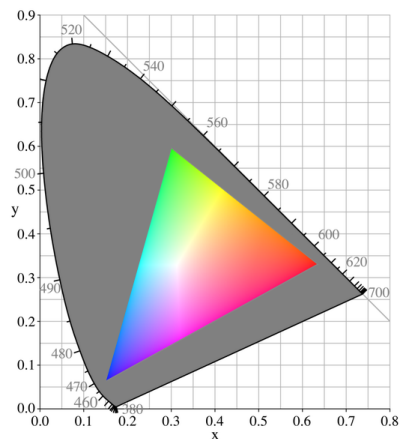
- Let's mix colors!



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

Color Theory

- sRGB space



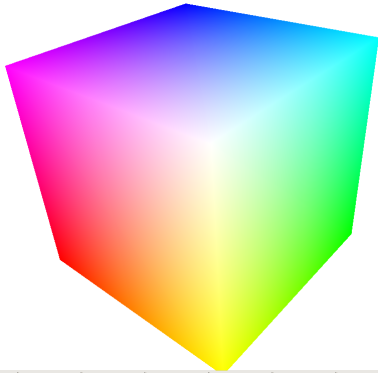
Color Theory

Intuitive colors?

RGB is not necessarily intuitive with human color perception.

Color Theory

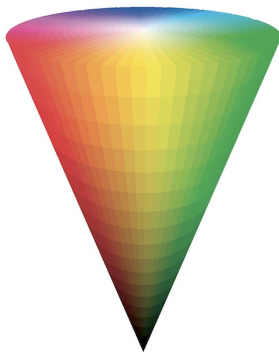
- RGB model



Visual Computing, Nielsen et al.

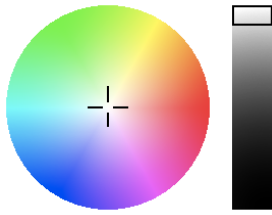
Color Theory

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



Color Theory

- HSV model



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

Tone mapping

- 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?

$$n = \frac{L}{L_{max}}$$

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

Tone mapping

- Many, many more mappings...
 - Average luminance scale

$$n = 0.5 \cdot \frac{L}{L_{avg}}$$

- Preserve color ratios
- Separate reflectance and illuminance

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

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- **Image representation**
- Signal processing
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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

Image representation

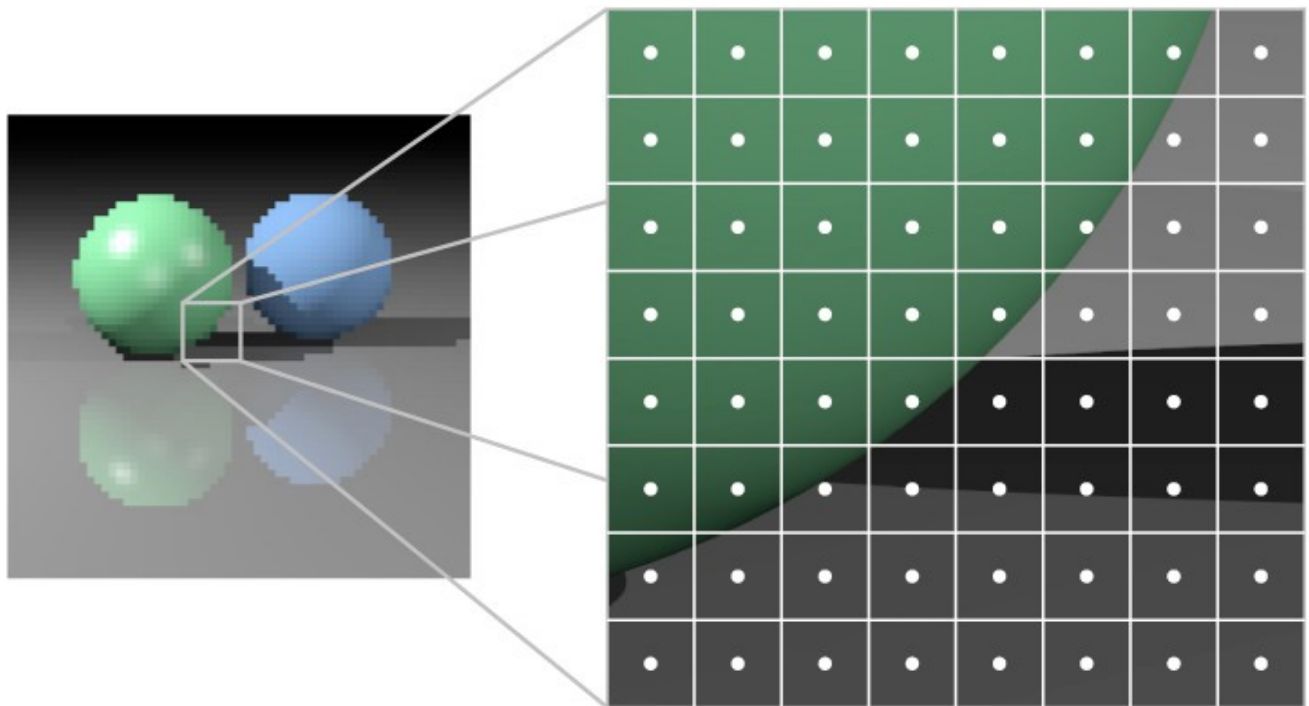
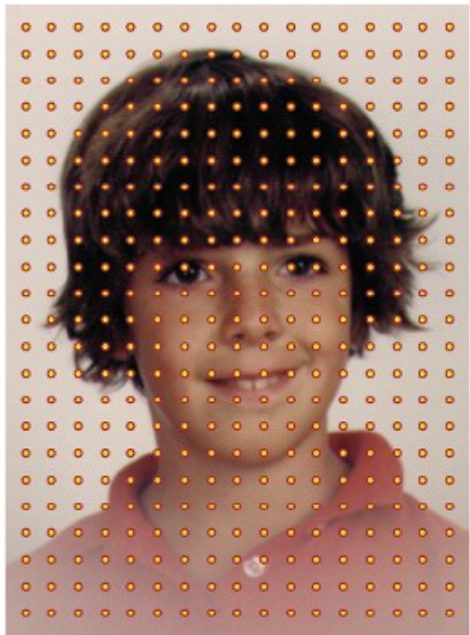
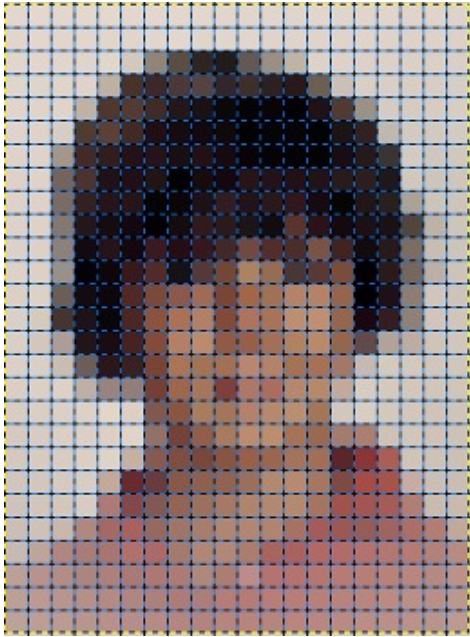


Image representation

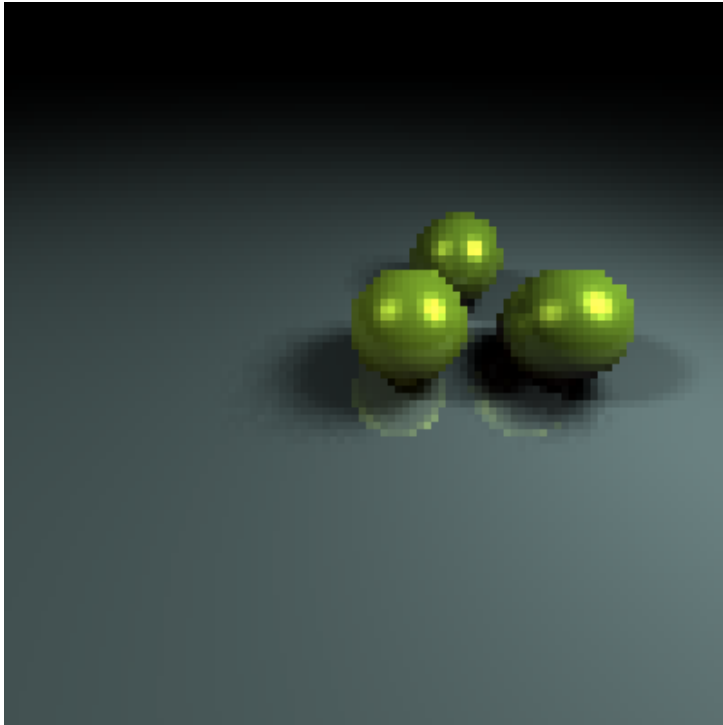
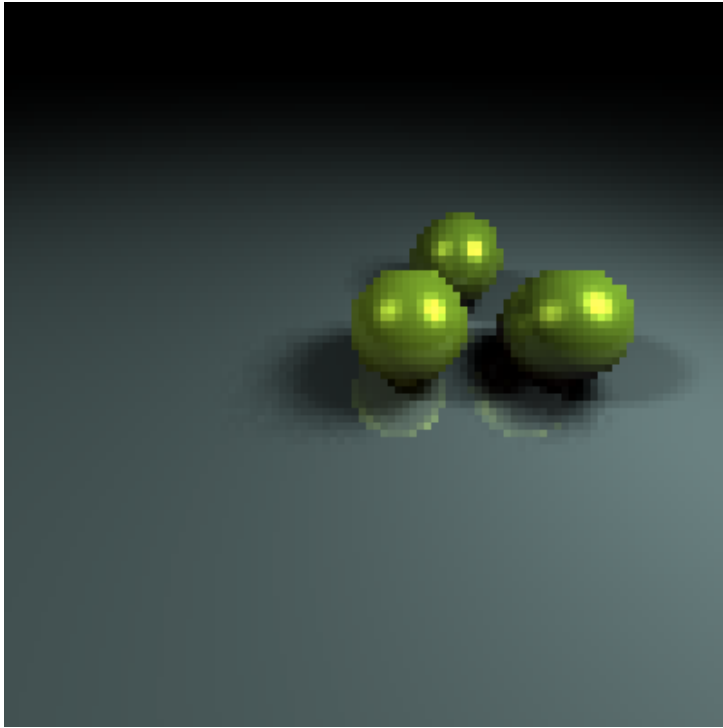
- What is a pixel?
 - Little box of color?



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