Color

Elements of Graphics
CS324e
Spring 2018
Student Presentation
Color Models

- Final color derived from combination of light sources
- Additive color models add light sources
- Subtractive color models subtract light sources

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Additive vs Subtractive

❖ Painting is subtractive (white surface)
❖ Computer monitors are additive (black surface)
Digital Color

❖ Each pixel has three light elements:
  ❖ Red
  ❖ Green
  ❖ Blue

❖ Light element intensity range from 0 to 255
  ❖ 0 means color is transparent (least intensity)
  ❖ 255 means color is fully opaque (highest intensity)
RGB

- Red: (255, 0, 0)
- Green: (0, 255, 0)
- Blue: (0, 0, 255)

- Colors at full opacity tend to be a little garish!
- Processing includes a color selector for more intuitive color selection if you don’t have access to digital paint program
Hexadecimal

- Color notation useful for HTML and CSS
- RGB color (0 - 255) encoded as a two-digit base 16 value
- Examples:
  - #000000 $\iff (0, 0, 0)$
  - #FFFFFF $\iff (255, 255, 255)$
  - #6699CC $\iff (102, 153, 204)$
Color Depth

- 1 bit can represent 2 values \((2^1)\)
- 2 bits can represent 4 values \((2^2)\)
- 4 bits can represent 16 values \((2^4)\)
Question

- How many color values can 8-bits represent?
  - A) 8
  - B) 64
  - C) 256
  - D) 768
True Color

- Supports three 8-bit channels (RGB)
- Supports 24-bits total or 16,777,216 values ($2^{24}$)
- The human eye can discriminate around 10M colors
- RGBA adds a fourth channel for alpha (transparency)
Note that any RGB model is limited to colors within the RGB gamut — such models cannot represent all human-visible colors!
Image Formats

- **GIF**
  - Color depth: 1-bit to 8-bit
  - Transparency: 1-bit

- **JPEG**
  - Color depth: 24-bit
  - Transparency: None

- **PNG**
  - Color depth: 1-bit to 24-bit
  - Transparency: 8-bit
Setting Color in Processing

❖ `background(int red, int green, int blue)` sets the color of the window in terms of RGB

❖ `fill(int red, int green, int blue)` sets the color for any subsequent shape primitives

❖ `fill(int red, int green, int blue, int alpha)` includes a transparency channel to modify opacity
Using the color Primitive

- Processing has a special primitive for color:
  - `color(float red, float green, float blue);`
- Can be used in `fill`, `stroke`, `background` functions
Consider...

color c = color(255.0, 255.0, 0.0);
fill(c);
rect(0, 0, 200, 200);
Transparency and Blending

- Transparency (alpha channel) also ranges from 0 to 255
- Transparency allows for on-screen color mixing based on the blend mode
- Default blend mode is BLEND
  - `blendMode(BLEND)`
A is source image
B is destination image
Factor is source alpha

**ADD**
Additive blending with maximum value of white:
\[ C = \min(A \times \text{factor} + B, 255) \]

**SUBTRACT**
Subtractive blending with minimum value of black:
\[ C = \max(B - A \times \text{factor}, 0) \]

**LIGHTEN**
The lightest color is used:
\[ C = \max(A \times \text{factor}, B) \]

**DARKEN**
The darkest color is used:
\[ C = \min(A \times \text{factor}, B) \]

**MULTIPLY**
Multiply the colors, result will always be darker:
\[ C = A \times B \]
Color Theory

- The study of color interactions
- Color classification
- Color mixing
- Color design
- Cultural context

RYB color model: primary, secondary, tertiary
Warm vs Cool

- Warm colors (yellow, orange, red, tan)
  - Active
  - Advancing
  - Stimulating
- Cool colors (green, blue, violet, gray)
  - Passive
  - Receding
  - Relaxing
Achromatic and Monochromatic

- Achromatic colors schemes are neutral (white, black, gray)
- Unsaturated colors are near neutral (tans, pastels)
- Monochromatic schemes focus on value using a single hue

Picasso
Complementary

- Complementary schemes use colors on opposite ends of the color wheel
  - High contrast
  - Dramatic
  - Forces eye movement

Van Gogh
Split Complementary

- Split complementary schemes use a color and the color adjacent to its complement
- Subtle contrast
- Balanced tension

Vermeer
Analogous schemes use adjacent primary, secondary or tertiary colors.

- Harmonious
- Moody

Monet
Color Triad

- Triadic schemes use three equidistant colors along the wheel
  - Balanced
  - Vibrant
Tetradic and Square

Tetradic color scheme

Square color scheme

(from Tiger Color)
Hands-on: Using Color

❖ Today’s activities:

1. Use Processing’s color picker to incorporate multiple colors via `fill` and `stroke`  
2. Store color primitives in an array for reuse  
3. Use `blendMode` to affect color interactions  
4. Create an image using one of the color theory schemas listed after this slide: achromatic, monochromatic, complementary, split complementary, analogous, color triad, tetrad, or square