Color

Kwan-Liu Ma

Outline

• Purpose of color
• Color selection and design
• Color in information display

This lecture is largely based on E. R. Tufte’s *Envisioning Information* and M. Stone’s *A Field Guide to Digital Color*
Purpose of Color

- To label
  Color as a noun
- To measure
  Color as quantity
- To represent and imitate
  Color as a representation
- To enliven and decorate
  Color as beauty

Above all, do no harm - E. R. Tufte

Color and Information, Envisioning Information, E. r. Tufte

Some Facts about Color Perception

- Average viewers can distinguish among 20,000 colors. For encoding abstract information, however, we should not use more than 20 or 30 colors

- Tristimulus theory: The retina has 3 kinds of color sensors

- Humans can distinguish about 28 fully saturated hues

- Humans can distinguish about 23 different levels of saturation for a fixed hue and lightness at the extremes of the spectrum. This drops to 16 levels at the center of the spectrum.
Color Selection and Design

- Create a functional and aesthetic result
- Traditionally taught by example and experience
- In perceptually organized color spaces
- Guided by the principles of color harmony
- Use contrast to focus attention, and analogy to unify design
- Be aware of interactive contextual effects
- Accommodate viewers and media

Physical Color Spaces

- RGB: Additive
  - Electronic Media

- CMY: Subtractive
  - Printed Media
Perceptual Organization of Color

Color Wheel

Hue circle for design

Printers Inks
Color Scale

Perceived Luminance

L from HLS

Luminance Y

$L^*$
Controlling Value

- Legibility and sharpness are defined by contrast in value
- The same value achieves equivalent importance

Color on Color

Chromatic aberration
Chromatic aberration

Very saturated blue color text is hard to read on a black background.

Yellow is much better.

Interactive contextual effects
Color on Color

Interactive contextual effects

Color in Information Display

- Select colors for information display to produce an image that is attractive and that conveys its message efficiently
- Principles of color designs
- Robust across media, viewing conditions, and viewers
- Color use poorly can be worse than no color at all
Principles of using Color

1. Avoid pure, bright or very strong colors for large adjacent areas
2. Avoid placing light, bright colors mixed with white next to each other
3. Use muted, grayish or neutral color for large area background
4. Avoid giving several large, enclosed areas different colors.
5. Use colors found in nature

Color and Information, Envisioning Information, E. R. Tufte

Emphasis and Grouping

careful color
careful color
careful color
careful color

A Field Guide to Digital Color, Maureen Stone
To Label

• An preattentive process
• Effective with a small number of colors

To Quantify

• Using color scales
• There is no perceptually-based hue scales
• A qualitative scale simply labels

- A sequential scale indicates quantity

- A diverging scale is two sequential scales cross-fading through a neutral color
To Quantify

http://www.colorbrewer.org

A Field Guide to Digital Color, Maureen Stone
Mapping Census 2002
Multivariate Scale

To Express

Color Scheme Imaging
To Express

Color Scheme Imaging

To Represent and Imitate

Left: Henrik Wann Jensen 2002

Copyright 2004 Institute of Mathematics and Computer Science, University of Hamburg
A Complete Example

Geologic Map of Washington

http://www.uwgb.edu/dutchs/StateGeoIMaps.HTM
# Resistor Color Code Guide

## Resistor Color Code Guide

<table>
<thead>
<tr>
<th>COLOR</th>
<th>1st BAND</th>
<th>2nd BAND</th>
<th>3rd BAND</th>
<th>MULTIPLEXER</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1Ω</td>
<td>± 1%</td>
</tr>
<tr>
<td>Red</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100Ω</td>
<td>± 2%</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1kΩ</td>
<td>± 5%</td>
</tr>
<tr>
<td>Yellow</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>10kΩ</td>
<td>± 10%</td>
</tr>
<tr>
<td>Green</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>100kΩ</td>
<td>± 20%</td>
</tr>
<tr>
<td>Blue</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1MΩ</td>
<td>± 50%</td>
</tr>
<tr>
<td>Violet</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>10MΩ</td>
<td>± 1%</td>
</tr>
<tr>
<td>Gray</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>100MΩ</td>
<td>± 0.25%</td>
</tr>
<tr>
<td>White</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>1GΩ</td>
<td>± 0.05%</td>
</tr>
</tbody>
</table>

**4-band code**

- 0.1%, 0.25%, 0.5%, 1%
- 2.2kΩ ± 1%

**5-band code**

- 0.1%, 0.25%, 0.5%, 1%
- 2kΩ ± 1%
Thunderstorm Visualization

Redesigned Storm Visualization

After the Storm: Considerations for Information Visualization

Polly Baker, Colleen Bushell
Color Scales for the Visualization

Guidelines

• Use a few colors (5-6 ± 2)
• Colors should be unique and distinct
• Avoid fully saturated colors
• Use contrast and value for emphasis
  – Red and blue vibrate
  – Surrounding colors affect color
• Color harmony
  – Complimentary and analogous colors
  – Tones and tints
• Get it right in black and white