Color in Visualization

ICS 288: Visual Perception
Color selection and design

- Color harmony
- Constraint by practical and functional limits dictated by perception
  - Convention
  - Material cost
Principles

- Laid down in late 70s
- Changed little since then
- RGB, HSV or HSL
Principles

- Good design
  - Focus attention using contrast
  - Unifies using analogy
- Three primaries
  - Red, Blue and Yellow
- Three secondaries
  - Purple, Green and Orange
- Analogous together, contrasting opposite
  - Complement: highest contrast
Principles

- Different types of color blend
- Chroma scale
  - Same value and hue, but different saturation
  - Very difficult to reproduce
- Should produce good gray scale
Controlling color value

- Contrast in value critical for shapes and edges
  - Perceptually edges are more due to luminance contrast
  - Robust to grayscale conversion
- ISO standards specify 3-5:1 ratio
- Important for sharpness and legibility
- Different hue, same value for buttons, tabs
  - Denoting equally important entities
More commonly

- Artists think about gradation and mixtures that may not lie precisely along the perceptual dimensions
  - Tint – lightened desaturated hue by adding white
  - Tone – darkened and grayed by adding black
  - Shade – mixed with both white and black
More Commonly
Avoid Color on Color

- Strengthen or Weaken
- Simultaneous contrast
- Depth of field varies with wavelength
  - Low intensity leads to vibrating edges
- Low density of S cones
  - Avoid blue edges
- Combined with variation in DOF
  - Especially on dark backgrounds like black
Color Blend

- Commonly is hue-white and hue-black
- Blend shows artifacts, is a stress case
  - Quantization, linearity
  - Leading to contours
- Interpolation path in some space
  - How it looks depends on the space
  - RGB for monitor, CMYK for print
  - Gamut mapping causes problems
Color Schemes

- Many books on series of schemes
- Important for conveying the mood of content
  - Warm red and yellow palette - Vibrant
  - Cool blue and green - Muted
  - Saturated - Youth
  - Subdued/Unsaturated - Sophistication/Maturity
Color Harmonious Schemes

- Monochromatic
- Analogous
- Complementary
- Split complementary
Color Selection Tools

- 3D mapped to a set of 2D and/or 1D sliders
  - 3 slides each for a dimension (RGB, HSL)
    - Photoshop
- 2D chromaticity plane and 1D luminance slider
  - Powerpoint
- Some form of HSL or HSV
To label
  - As noun
To measure
  - As quantity
To imitate reality
  - As representation
To decorate
  - As beauty
Good and Bad Uses

- Should be clarifying - Not confusing
- Should be tasteful - Not clumsy
- Should be robust
  - Across media, viewers and viewing conditions
- Do no harm policy

(a) careful color (b) careful color
(c) careful color (d) careful color
- Legend – label
- Shape and height of terrain by shading – quantity to measure
- Blue water and brown land accented by green mangrove – representation
- Pleasant to look at – harmonious as well as informative
Maps

- Legend – label
- Shape and height of terrain by shading – quantity
- Blue water and brown land accented by green mangrove – representation
- Pleasant to look at – harmonious as well as informative
Medical Visualization

- No color in MRI
- Maps grayscales to densities
- Replacing grayscale with color
  - Pseudocolor

Yellow-green features
Color to Label

Slide 19

Aditi Majumder, UCI
Color to Label

- Very low level perceptual phenomenon
- Pop out feature
Can be used to group

Again due to pop-out feature
Color to Label

- Effective when a small number of colors are used against neutral background
  - Remember names instead of hues
- Information should not conflict with color names
  - e.g. green stop sign
- Cognitive influence
Color to Quantify

- **Most natural**
  - Scale that varies in value or saturation
  - Used in Cartography
  - Perceptually no hue scale

- **Qualitative**
  - Same value, different hue

- **Sequential**
  - Scale in value/saturation

- **Diverging**
  - Cross fade through neutral
Examples

7-class sequential YlGn
Examples

Percent change in total population from 1990 to 2000 by county

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<th>Range</th>
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Difficult to introduce color without causing confusion
Multivariate Data

- Univariate – Map to a line
- Bivariate – Map to a plane
- 3 variables – Map to a volume
- 2D – one dimension on value, another on saturation
  - Only one that is perceptually intuitive
  - Everything else has to be learned
- Using patterns with colors often help
  - Especially if it exploits the relationship across variables
Making color robust

- Accommodating viewers with anomalous vision
  - Good contrast in values
  - Reinforce with encoding in shape and size
    - Stop sign is hexagonal in addition to being red
Making color robust

- Accommodating different media
  - Gamut Mapping – lightening or darkening, hue shifts
  - Scales – Uniform and non-uniform
- Usually map a few key colors
  - Define some robust way to move between them in a consistent fashion