# Color… part 2

## Today

- 3 Readings for Today
  - "Color Design for Illustrative Visualization" Wang, Giesen, McDonnell, Zolliker, & Mueller, TVCG 2008
  - "Hue-Preserving Color Blending" Chuang, Weiskopf, and Möller, TVCG 2009
  - "A Linguistic Approach to Categorical Color Assignment for Data Visualization", Setlur and Stone, IEEE InfoVis 2015
- Show & Tell of your homeworks 3, 4, or 5?
- Reading for Tuesday

# Reading for Today: *(choose one)*

"Color Design for Illustrative Visualization"
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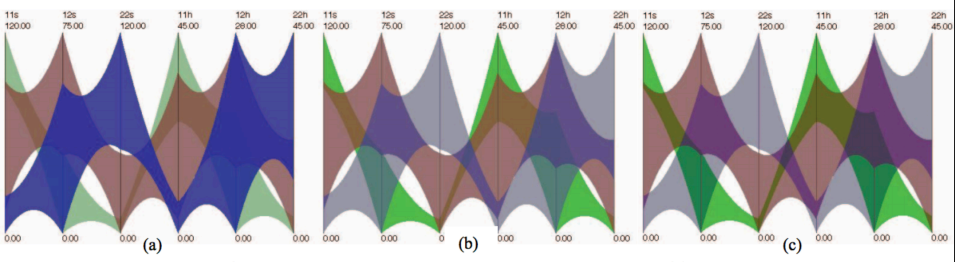



Fig. 12: Illustrative visualizations of a six-dimensional dataset using illustrative parallel coordinates. (a) Ideal visualization with appropriate weightings and color choices, and the use of the local model in overlapping areas. (b) Improper weightings are employed. The blue cluster no longer seems to be in front. (c) The use of improper weightings and the disabling of the local model results in a confusing visualization.

# 13 "rules"

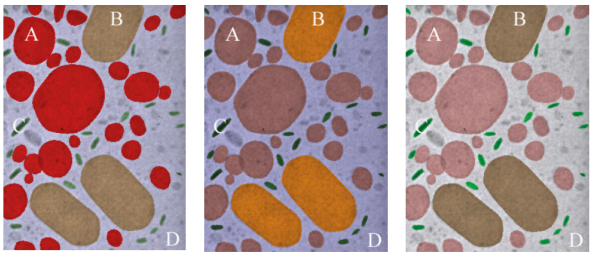



Fig. 6. Colorizations of Transmission Electron Microscopy (TEM) data. From left to right, classes A, B, or C (the small oblong, elliptical cells) were most important.

- Vivid colors pop (foreground vivid compared to background), too much vividness is bad
- Easier to distinguish colors if hue, saturation and value are different. Small things have effective lower hue, saturation, & value.
- Humans don't perceive light linearly (instead of 10 units brighter it should be 10% brighter)
- # of color labels <= 6-7
- …

- Help user select effective color palettes:
  - aesthetic (reduce stress), color harmony
  - attention grabbing, saliency
- Transparency (used by volume visualization & InfoVis) can yield problematic mixing effects
  - combination of colors makes a 3rd hue
  - confusion about depth order
- Want to better integrate human perception into visualization design
- Decouple (for this study) effects of color from illustrative style
- Increase/maximize simultaneous contrast
- Assign color based on visual importance

- Goal: colorization of classification
- User picks *hue* (personal preference or linguistic meaning?)
  - Hue is inter-class (between categories) contrast
- System optimizes to finds best *saturation* & *value*
  - Vividness/saturation used for highlighting
  - Lightness/value for intra-class (within class) contrast
- HSV -> LAB -> RGB
  - Does any data get lost with all this transformations?
- User study with 72(!) non-colorblind participants
  - Why not study the effectiveness of visualizations on colorblind people? They deserve better visuals too!
- Results:
  - Surprise result: cold colors (esp. blue) for foreground, warm colors for background was best
  - Hypothesis confirmed: Front objects should be lighter, back objects should be darker

- Writing Comments:
  - Stating the rules at the start is good…
    But the writing is hard to follow in places.
  - Caption that ends mid sentence
  - Not all choices explained, made intuitive (vividness from 0.3->1.0… what about 0.0-0.3?)
  - Confusing use of foreground/background interior/outside/ exterior terms
  - Figures could be simplified, made more consistent
  - Global vs local(?)

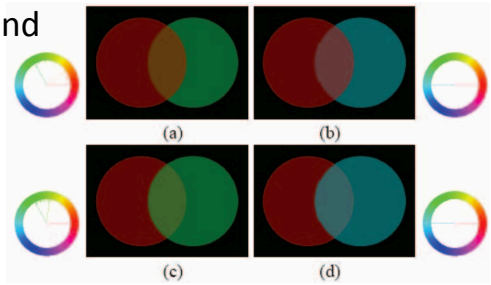
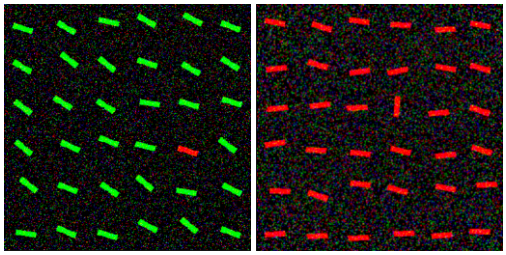


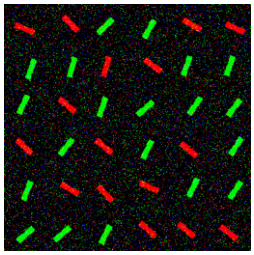

Fig. 7. Two color mixing examples. (a) and (c) Red and green are mixed with red in front or green in front. (b) and (d) Red and cyan are mixed with red in front or cyan in front.

# Visual Salience

Laurent Itti (2007), Scholarpedia, 2(9):3327.
http://www.scholarpedia.org/article/Visual_salience

- … is the perceptual quality that makes some items in the world stand out from their neighbors and grab our attention





- Designers use saliency to create objects (such as this emergency triangle) that appear highly salient in a wide range of viewing conditions

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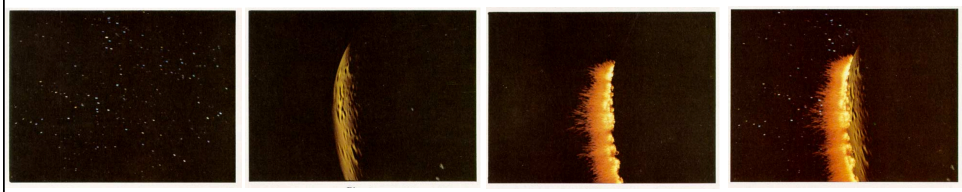
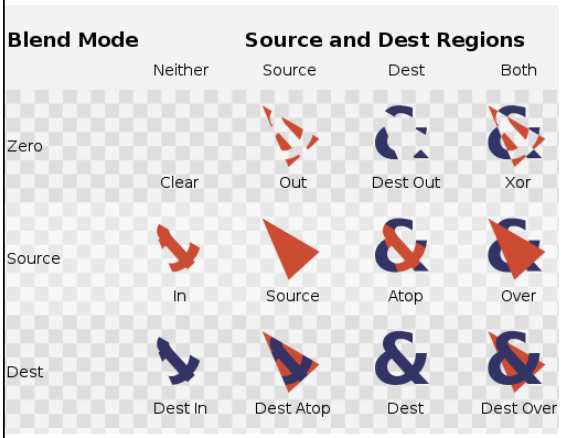
# "Compositing Digital Images" Porter & Duff, SIGGRAPH 1984

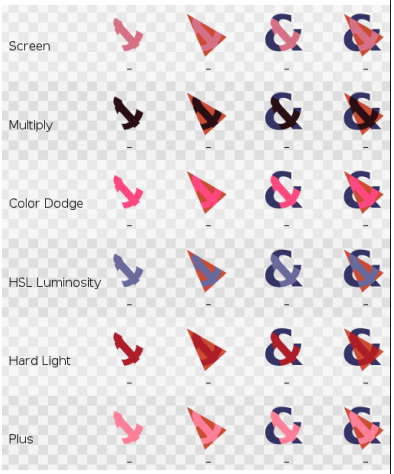
- Impractical to make a single system render entire image
- Instead separate into *elements*, use a *matte* to define boundaries, and *composite* into a final image
- Soft edges
- 2 ½ D (overlapping layers)
- The alpha channel, RGBA



http://graphics.pixar.com/library/Compositing/paper.pdf


Søren Sandmann Pedersen
http://ssp.impulsetrain.com/porterduff.html

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"Hue-Preserving Color Blending"
Chuang, Weiskopf, and Möller, TVCG 2009

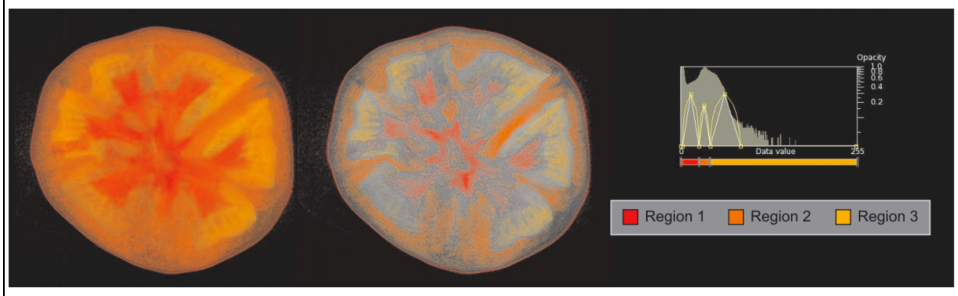
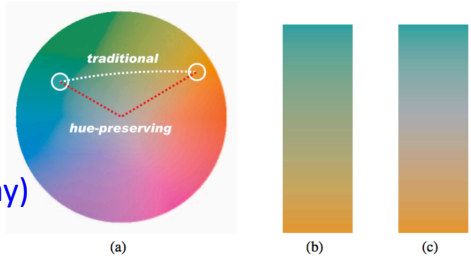


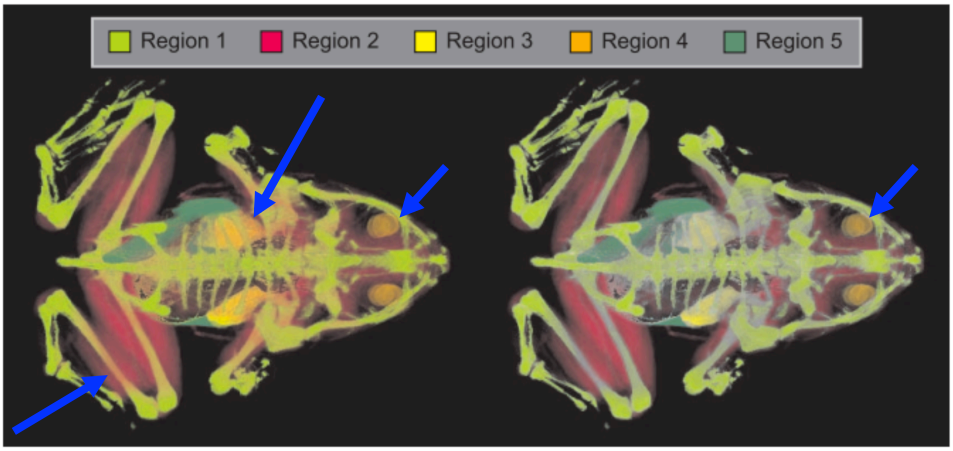

Fig. 1. Volume rendering of a tomato data set using traditional (left) and hue-preserving (middle) color blending. The data histogram, transfer function, and color legend are shown on the right.

- Color is particularly effective for visual grouping
- Volume visualization classifies data into material components -> want to visualize these regions
  - Great potential for application to medical data
- Opposite colors should be used for semi-transparent layers to avoid hue shift after alpha blending
  - Just a small change in the traditional method
  - No change (if colors are already opposite), or
  - More significant change (forcing blend through gray)




- Clearly states:
  - Observations (from perception research),
  - Design criteria (wants), and
  - Requirements (compromise of wants)

Region 4 = eyes
(only the eyes
should be orange)




original hue preserving

- Example images were very well chosen
- "when using many colors of different hues, I get a blended hot mess of color that completely washes out and detail of the underlying 3D rendered model"
- Long sections could be broken up with subsection titles
  - limitations/drawbacks is buried in the middle of "results" (not enough attention paid to negatives?)
- The Matlab "jet" color scheme is the default (and it looks so pretty!), but it is misleading!

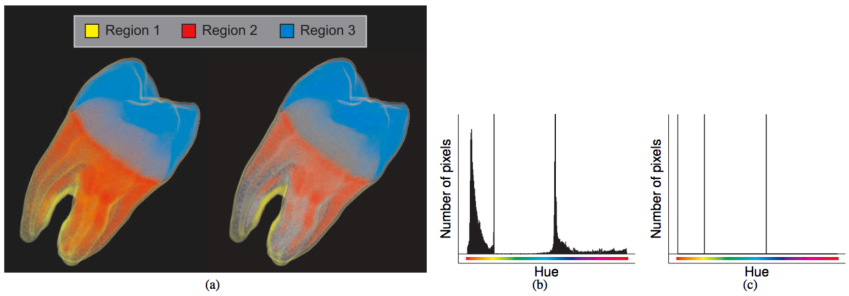




Fig. 7. (a) Traditional (left) and hue-preserving (right) rendering of a tooth data set. In the traditional rendering, orange colors can be seen where red and yellow mix. There are also purple hues where red and blue mix. These extraneous hues completely disappear in the hue-preserving rendering. The color hue histograms for both renderings are shown in (b) and (c). Note the three vertical lines in the hue-preserving histogram, representing the original color hues.

- Is this too lossy? Are we highlighting the important data or just showing the easy to present data?
- Needs a user study, with real case studies, and domain experts, measuring accuracy in domain-specific analysis

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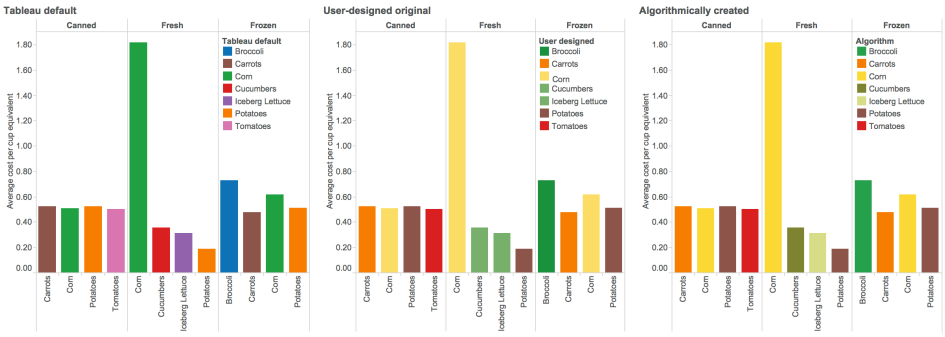
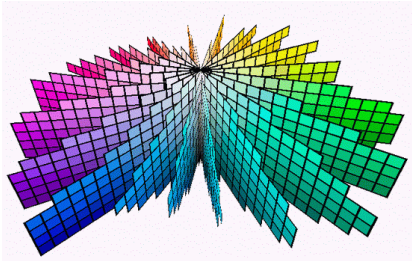



Fig. 1. This visualization was taken from a Tableau Public workbook [11] to illustrate the value of semantic color encoding. Left: The Tableau default colors are perceptually legible, but conflict with the data semantics ('Tomatoes' are pink, 'Corn' is green). Center: The Tableau author matched the colors to the data semantics (red for 'Tomatoes', yellow for 'Corn'), which makes it easier to identify the different types of vegetables in the graph. Right: Our algorithm automatically created a similarly effective result.

| | | | | |
|---|---|---|---|---|
| RED | GREEN | BLUE | YELLOW | PINK |
| ORANGE | BLUE | GREEN | BLUE | WHITE |
| GREEN | YELLOW | ORANGE | BLUE | WHITE |
| BROWN | RED | BLUE | YELLOW | GREEN |
| PINK | YELLOW | GREEN | BLUE | RED |

Stroop Effect
http://faculty.washington.edu/chudler/words.html



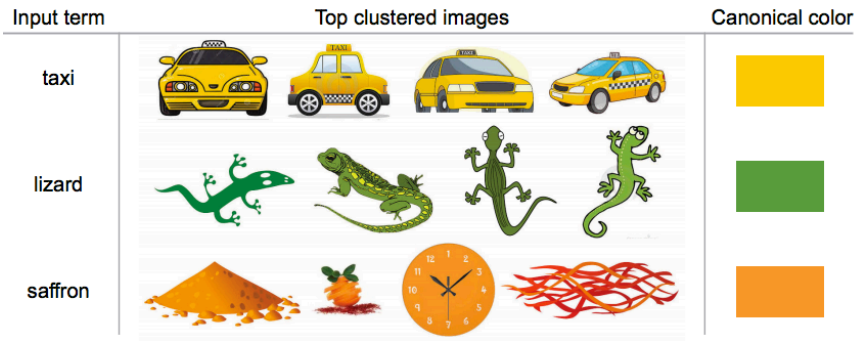
Musell Color System
http://www.codeproject.com/Articles/7751/
Use-Direct-D-To-Fly-Through-the-Munsell-Color-So

TableauColors


- Is a word colorable?
  - Use Google n-grams to find # of times it is associated with color (books only? Would this be even better if they had a general human speech corpus?)
  - Are there strong color associations for a word?
- What is the best color value?
  - google images (clipart or natural images?)
- Semantic context
  - apple the fruit or apple the company?
  - NLP (Natural Language Processing)
- K-means clustering to create set of distinct colors (flexibility of different colors for some items)

- *"The power of these names is not their accuracy, but their memorability and ease of use."*

- Berlin & Kay's 11 basic color terms:
  - black, white, red, green, yellow, blue, brown, purple, pink, orange, gray
- Why clipart?




- Query expansion, Ontology, Concept tree

- Not surprised that it performs poorly for logos
- Even if the results are always perfect, this can be a huge timesaver! And expand what colors we should consider.
  - Why limit choices to Tableau 20? Why not pantone? Or Munsell?
- Good scientific organization to paper
- Larger datasets & statistics always(?) better than surveys
  - Presented algorithms are entirely dependent on these datasets
- Impressive result for 2 different fields (could alternatively be a paper in an NLP conference)
- Lots of detail in the paper (good for reproducibility)… but also feels like lots of padding/redundancy in the paper? (same example used multiple times)
- Discussion could be stronger/more complete
  - Competitor's results often (always?) seemed better…
- Xkcd is awesome
- Sentiment analysis (sorta creepy)
- Why include poem?

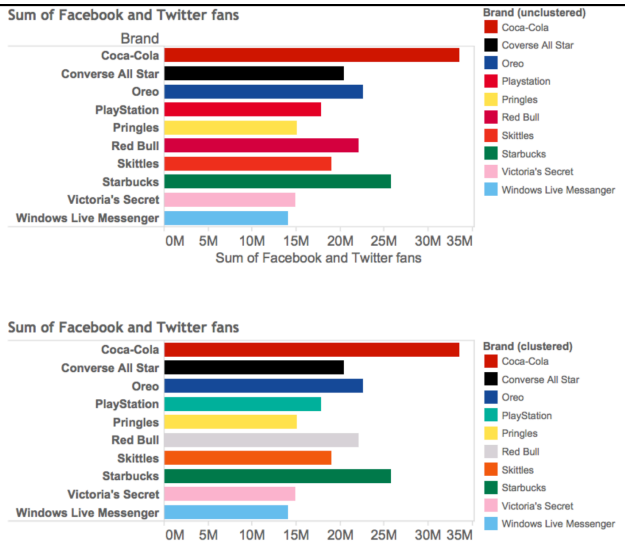



Fig. 12. Top row: A Tableau Public visualization [11] semantically color encoded with our algorithm before clustering is applied. One can observe several brands colored with shades of red. Bottom row: Once clustering is applied to the set of colors, some of the reds are replaced by alternate canonical colors obtained from the corresponding logo images.

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- "Stacked Graphs – Geometry & Aesthetics"
  Lee Byron & Martin Wattenberg, IEEE TVCG 2008