Two papers on

Color

Presented by Anirban Sinha (Ani)

Focus Area

- Importance of luminance & luminance contrast in color maps for visualizing human recognizable elements in photos.
- Design of a technique to use man’s complex power of face recognition in constructing a color map with uniform predetermined luminance variation.

Paper # 1

The “Which Blair Project”: A Quick Visual Method for Evaluating Perceptual Color Maps

Bernice E. Rogowitz

Alan D. Kalvin

Visual Analysis Group, IBM T.J. Watson Research Center, Hawthorne, NY

Target of this paper

- How important is luminance in showing the "naturalness" of an image.
- How & in which degree are we sensitive to luminance variations.
- Propose a thumb rule for designing an effective color map for depicting natural images more effectively, specially in internet environment where color rendering properties on the client side is unknown.

Methodology used

- Taken 8 colormaps.
- Map these color maps (& their subsections) to the intensity values of digital photo, that of "Tony Blair".
- Judge the naturalness of the images by putting them across 17 observers & allow them to grade the photos in a scale of {-2, -1, 0, 1,2} from very bad to very good.
- Plotting the scores in bar charts & analyzing.

Color Maps used

- Monotonically Increasing Luminance
  - LAB grey Scale (L*, a*, b*)
  - Heated Body (HSV)
  - HSV grey Scale
  - HSV decreasing Saturation
- Constant Luminance
  - LAB Isoluminant Rainbow
  - LAB Isoluminant Saturation
- Decreasing Luminance
  - HSV increasing Saturation
- Irregular Luminance
  - Rainbow (RGB)

Color Map Family

- Normalized the range of each of the colormaps to a scale of [0-99] & subdivided each full range into 7 overlapping quarter sub segments
  - [0-24], [2-36], [25-49], [37-61], [50-74], [62-86], [75-99].
- Total 64 scales (8 full range & 56 quarter range).
- 34 scales has monotonic increasing luminance.
- 16 scales with no luminance variations.
- 10 scales with monotonic decreasing luminance.
- 4 scales with irregular variance.

Results

- Consistently positive judgments for those scales having monotonically increasing luminance value.
- Moderately low judgments for those scales with monotonically decreasing luminance.
- Very poor performance for scales with uniform luminance.
- Luminance contrast (rate of change of luminance across hue) has a greater impact than the hue range.
- When luminance contrast exceeds 20%, 70% of the score ratings are positive.

Conclusion

- Use a colormap that has a monotonically increasing luminance.
- Use strong luminance contrast, preferably exceeding 20% in your color map.

Critique

- It would be interesting to see the analysis on other different kinds of images.
- None of the graphs or the test images were available in color print. It was difficult to see the conclusion from the graphs otherwise.
- I did not quite understand figure 8 that tries to establish strong correlation between luminance contrast & better perception of images. The representation used is poor, more so with non-availability of color.

Comparing Luminance Contrast

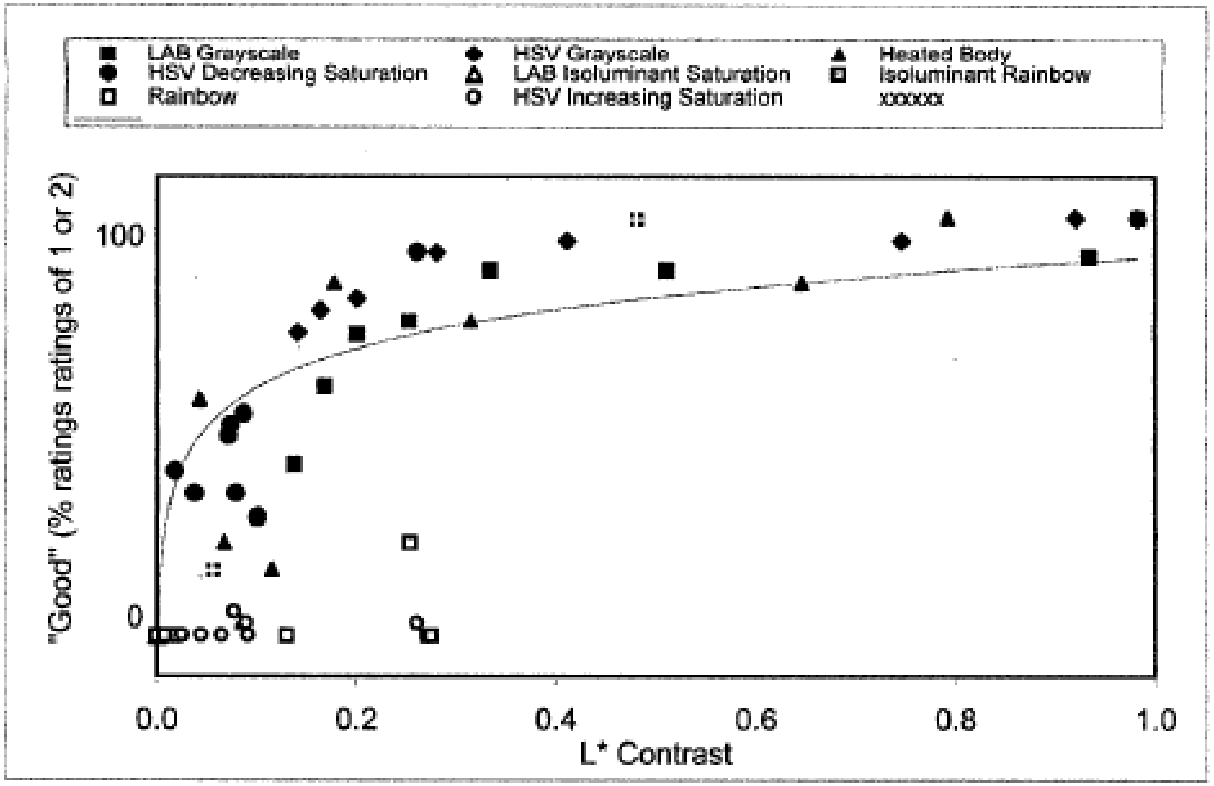


Figure 8: The relationship between L* contrast and percentage of favorable ratings. This relationship is logarithmic for color scales having monotonically increasing luminance.

Critique Continued …

- I think a better analysis could have been done by taking two separate sets of color maps,
  - One with strong monotonic luminance increase with good contrast (of varying degree).
  - Other with constant luminance.
- Plot separate graphs for the first set & another taking the best case of the first set with a sample case from the second set & compare.

Paper # 2

Face-based Luminance Matching for Perceptual Colormap Generation

Gordon Kindlmann – *School of Computing, Univ. of Utah*

Erik Reinhard – *School of EE + CS, University of Central Florida*

Sarah Creem – *Department of Psychology, Univ. of Utah.*

Importance of Luminance & The Target of The Paper

- We have seen luminance is really critical in helping us to identify image structure, terrain, surface etc.
- Control of luminance is difficult because display device is uncalibrated, varied lighting conditions of the room, human physical variations from person to person etc.
- Propose an elegant solution for controlling luminance across a color map.

The Proposed Approach

- A fixed reference color (shade of gray) with a specific luminance value is compared to another color with varying luminance using face recognition.
- Can be used to construct a color map with constant luminance values or uniformly varying luminance.

Methodology

- Use two copies of a black & white image of a human face placed side by side with one in reversed black & white regions.
- Replace the black region with a shade of gray with known luminance & the white with a specific hue (color) with varying luminance.
- If there remains a large variation of luminance between gray & color regions, one of the images appear positive, another appear negative.
- Vary the luminance of the color (L in HLS space) until neither face appears positive or negative.
- Record the luminance value of the specific color causing transition.

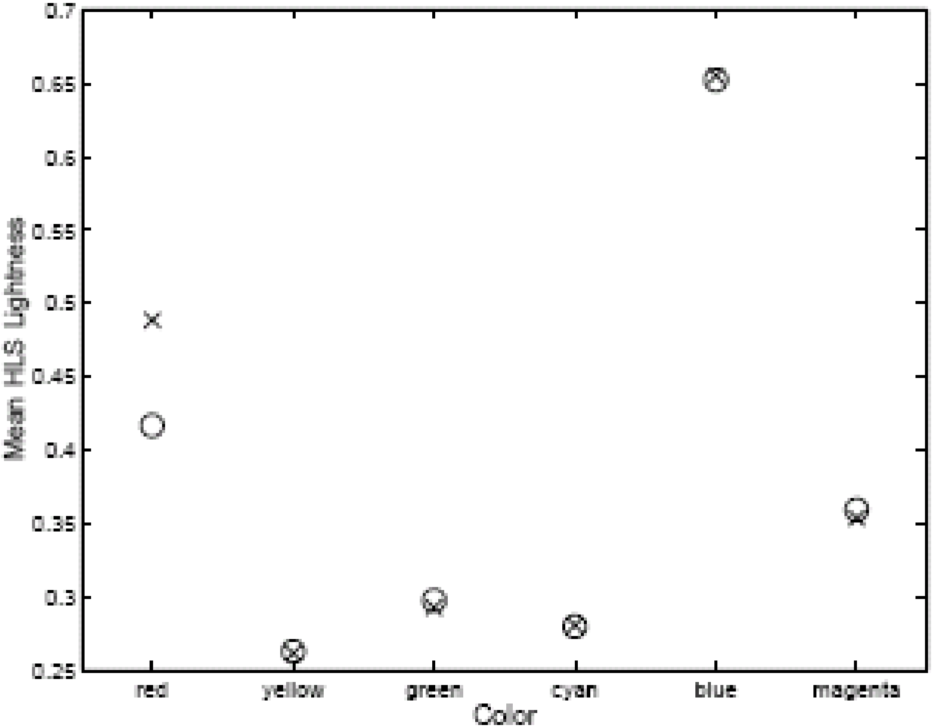
Test image used

Compare face-based luminance measurement approach to MDB approach

- MDB method is free from Helmholtx-Kohlrausch effect
  - Saturated colors tend to “glow” with a brightness out of proportion to their actual luminance.
  - Read about it in details in this paper:
    - *G Wyszecki and W S Stiles. Color Science: Concepts and Methods, Quantitative Data and Formulae. John Wiley and Sons, New York, 2nd edition, 1982.*
  - Two images are placed side by side & their luminance adjusted until the border is just minimally visible.

Test Pattern Used for Comparison …

Results



(a) Mean HLS Lightness for each color and task (x: MDB, o: face), averaged across participants.

Performance of face based method almost the same as the MDB approach.

Colormap Generation with Uniform Luminance

- But we took only 6 hue samples, how do we have a uniform continuous colormap??
- Solution: Interpolate using the formula:

$$c_f = \begin{pmatrix} ((1-f){r_0}^{\gamma} + f{r_1}^{\gamma})^{1/\gamma} \\ ((1-f){g_0}^{\gamma} + f{g_1}^{\gamma})^{1/\gamma} \\ ((1-f){b_0}^{\gamma} + f{b_1}^{\gamma})^{1/\gamma} \end{pmatrix}$$

  - Where $c_0=(r_0,g_0,b_0)$ & $c_1=(r_1,g_1,b_1)$ & C_f is a color in between C_0 & C_1 & f is a parameter $\in [0,1]$.

How to estimate Monitor Gamma??

- Replace the black region of the image by a grayscale color with varying luminance & the white portion by alternate stripes of black & white which has a uniform intensity half of that of white independent of the gamma.
- Adjust the intensity level of the gray region to that of the shaded region similar to the previous experiment.

How to have varying luminance with hue???

- Well, Simple really!
- Previously, the luminance level of gray region was constant for every hue value.
- Now, just vary the gray scale luminance in the experiment for every different hue & then interpolate.

Critique

- Well, what's the ideal sample size for this experiment to represent a true illumination measurement for the mass? Is 12 participants really representative of the human population?? Doubtful.
- How to exactly pinpoint the transition zone?? Different people will have different opinions about this. Any specific guidelines??
- It would be really interesting to see whether luminance varies with aging.
- How do we know that the monitor used was a “standard” one?? No monitor specs? Will the calibration obtained be different of we used a separate monitor?
- Why flip the test images for MDB analysis? It wasn’t very clear reading the paper though.

Questions & Discussion …