“Color Harmonization”

• SIGGRAPH 07
  Daniel Cohen-Or et al
  Daniel is a professor at the Tel Aviv University in Israel
  He has many SIGGRAPH papers every year.

• Idea
  Harmonization is the result of choosing colors that are pleasing to humans
  - Can we provide a way to do this for images?
  - Retarget colors to be harmonized?
First to remember color
HSI Manipulation Examples

Hue

Saturation

Intensity
Another example

original

Hue modification

Saturation modifications

Lightness modifications
What is color harmony?

- Harmonic colors are pleasing to the eye.
- They engage the human observer and give a sense of order and balance in the visual experience.

[slides from Cohen-Or’s SIGGRAPH talk]
Formal definition of color harmony?

- Mathematical formulation has been developing together with color theory – Newton, Goethe, Young, Maxwell
- Itten [1960]: harmony means relationships on the hue wheel:
  - 2-color harmony: complementary colors
  - 3-color harmony: equilateral triangle
  - N-color harmony: equilateral N-gon
Formal definition of color harmony?

- Matsuda [1995]: extensive empirical studies, derived 8 hue templates
- Tokumaru et al. [2002] developed a fuzzy system to evaluate the harmony of color schemes
Harmonic scheme

• The templates can be arbitrarily rotated
• Harmonic scheme is template type $T_m +$ specific orientation $\alpha$

Type “N” is not considered in this paper, this is for grayscale images.
Harmony score

- To evaluate the harmony of an input image $X$ we analyze its hue histogram:
  - Every pixel $p$ contributes its saturation $S(p)$ to the bin of the hue $H(p)$
Harmony function

• The harmony of image $X$ w. r. t. harmonic scheme $(T_m, \alpha)$:

$$F(X, (T_m, \alpha)) = \sum_{p \in X} \| H(p) - E_{Tm(\alpha)}(p) \| \cdot S(p)$$

This term is the closest edge of the template (oriented at angle alpha)
Harmonization

• Given \((T_m, \alpha)\) we shift the hues so that the hue histogram is contained in \((T_m, \alpha)\)
The problem, no way to force neighboring pixels to similar colors.

Here, similar colors (blue) move to two different regions (green, purple).
Color coherency

• Another example
Graph-cut optimization

• To make the coloring more coherent we assign $E_{Tm(\alpha)}(p)$ by optimizing the labeling $V$

$$E(V) = \lambda E_1(V) + E_2(V)$$

Favors short distance to the template sector

Favors coherent labeling of neighboring pixels

[Back to MRF – each pixel now has a data-cost $E_1$ and a neighbor cost $E_2$. This is similar to the lazy-snapping MRF formulation.]
Results
Overcoming segmentation problems

• The graph-cut may fail when an object in the image has several connected components
Overcoming segmentation problems

• User-assisted fix: scribbling on the erroneously labeled area
• Re-compute the labeling
Results – choosing colors
Results – cut and paste

- The background is harmonized according to the best-fitting harmonic template of the pasted foreground.
Results

• Text over a poster
Results

• Text over a poster
Results

Images harmonized to different “flags” colors.

Find the flags template, force the image to this.
Discussion

• Nature is already harmonic
Discussion

• Cannot improve good artwork!

Wassily Kandinsky, Composition VII, 1913
Discussion

• Grayish colors will remain such
Harmony Summary

• Provides a method to enhance the harmony of colors in a given image
• Operates by fitting the image hues into a given harmonic distribution
  – Several different harmonic choices are predefined (based on color theory)
• Especially useful for ‘artificial’ colors, cut-and-paste settings and collages that combine imagery from different sources