

# Color harmonization

CVFX @ NTHU

26 Feb 2015

# Outline

Color harmonization

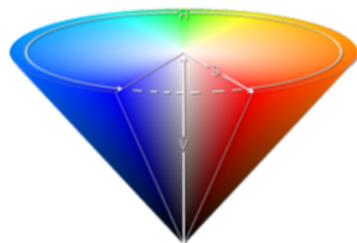
# Color harmonization and cConceptualization

“Color Harmonization” by Cohen-Or et al.

“Color Conceptualization” by Hou and Zhang

# HSV color space

- ▶ Hue, saturation, value
- ▶ Non-linear



# The paper

## Color Harmonization

Daniel Cohen-Or   Olga Sorkine   Ran Gal   Tommer Leyvand  
Tel Aviv University\*

Ying-Qing Xu  
Microsoft Research Asia†



original image



harmonized image

Figure 1: Harmonization in action. Our algorithm changes the colors of the background image to harmonize them with the foreground.

# In grayscale

## Color Harmonization

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original image

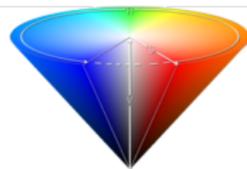
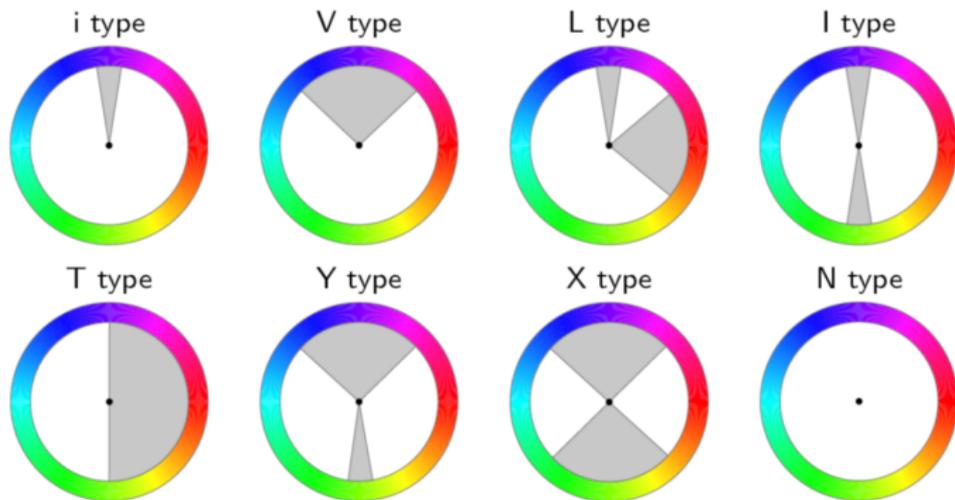


harmonized image

Figure 1: Harmonization in action. Our algorithm changes the colors of the background image to harmonize them with the foreground.

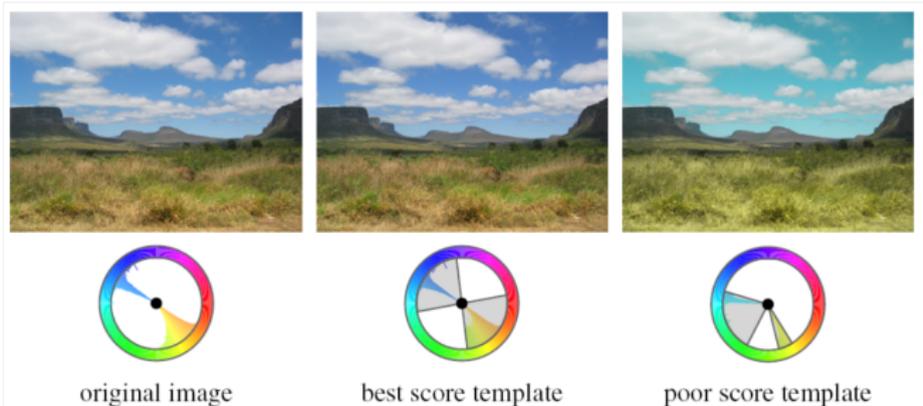
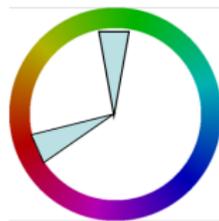


# Harmonic color scheme



[Cohen-Or *et al.*]

# Subjectiv? objective?



original image

best score template

poor score template

[Cohen-Or *et al.*]

# Analogy to sound

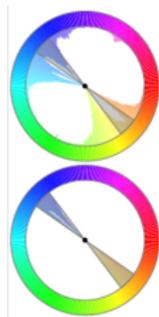
- ▶ Scales, chords

A musical staff in treble clef, 2/4 time signature, and D minor key signature (one flat, one sharp). The staff contains eight measures of chords, each represented by a vertical line with a chord symbol below it. The chords are: Dm7, Em7#5, Fmaj7#5, Gm7, A7#9, Bbmaj7, Cdim7, and Dm7. Below each chord symbol is a Roman numeral: I, II, III, IV, V, VI, VII, and I. The notes for each chord are indicated by vertical lines on the staff.

| Chord Symbol | Roman Numeral |
|--------------|---------------|
| Dm7          | I             |
| Em7#5        | II            |
| Fmaj7#5      | III           |
| Gm7          | IV            |
| A7#9         | V             |
| Bbmaj7       | VI            |
| Cdim7        | VII           |
| Dm7          | I             |

# Measuring the harmony

- ▶ One-dimensional optimization



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

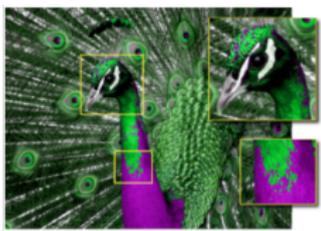
↑  
sector border hue

$$M(X, T_m) = (m, \alpha_0) \text{ s.t. } \alpha_0 = \underset{\alpha}{\operatorname{argmin}} F(X, (m, \alpha))$$

$$B(X) = (m_0, \alpha_0) \text{ s.t. } m_0 = \underset{m}{\operatorname{argmin}} F(X, M(X, T_m))$$

# Graph cuts

- ▶ Resolving ambiguities



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

$$E_1(V) = \sum_{i=1}^{|\Omega|} \|H(p_i) - H(v(p_i))\| \cdot S(p_i)$$

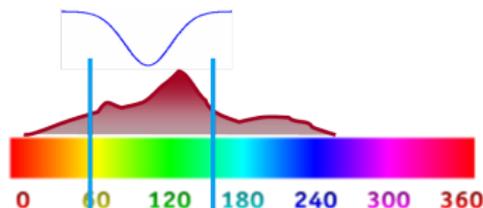
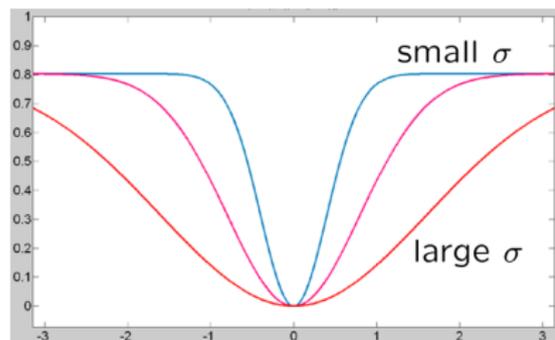
↑  
color of the assigned sector edge

$$E_2(V) = \sum_{\{p,q\} \in N} \delta(v(p), v(q)) \cdot S_{\max}(p, q) \cdot \|H(p) - H(q)\|^{-1}$$

4- or 8-connected neighborhood

- ▶  $\delta(v(p), v(q))$  equals 1 if  $v(p), v(q)$  are different

# Shifting colors



$$H'(p) = C(p) + \frac{w}{2} (1 - G_\sigma(\|H(p) - C(p)\|))$$

$$G_\sigma(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{x^2}{2\sigma^2}\right) \in (0, 1]$$

$$e^{-1/2} \approx 0.6065$$

# Problems mentioned by the authors

## Separated regions

- ▶ Adding scribbles by users
- ▶ Semantic segmentation: important research topic in computer vision



The shifting is many-to-one

Cannot change colors with low saturation

- ▶ Only alters the hue channel

# Future work mentioned by the authors

Keep certain colors unchanged, add hard constraints

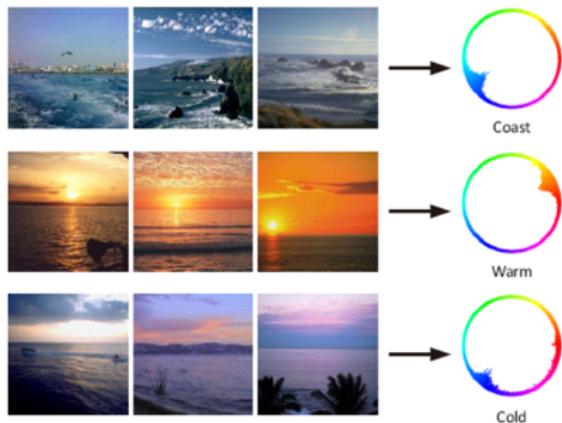
Histogram matching

# Color conceptualization

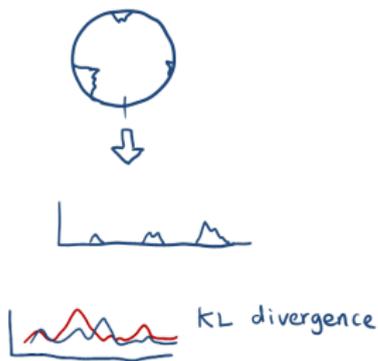
$$H_I(\theta) = \sum_{i(H)=\theta} i(S) \cdot i(V) \quad i \in I$$

Kullback-Leibler Divergence

$$D(i \parallel C) = \sum_{\theta} H_i(\theta) \log \frac{H_i(\theta)}{H_C(\theta)}$$



[Hou&Zhang]



# Discussions

## The methods of color harmonization & conceptualization

- ▶ How to implement these methods now?
- ▶ Graph cuts

## Problem modeling

- ▶ What are the variables and parameters?
- ▶ Objective function
- ▶ How to measure harmony?
- ▶ How to measure similarities?