Interactive Local Color Transfer Between Images

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Alla Maslennikova and Vladmir Vezhnevets
Presented by Ho-Gun Ha

School of Electrical Engineering and Computer Science
Kyungpook National Univ.
Abstract

◆ Proposed method
  – Interactive local color transfer based on local color statistics
    • Altering color of only a part of an image
      – Not modifying the rest of an image
      – Preserving image details and natural look
      – Simple and fast algorithm
Introduction

◆ Color transfer

– Image recoloring
  • Applying color scheme of one image to another
  • Partial image recoloring
    – Recoloring only on object or area of the image
    – Tedious and time consuming task
      » Totally manual mode

– Object of the proposed method
  • Saving user from the trouble of complicated manual work
    – Color statistic in selected region
Related work

- Global image recoloring
  - Using color statistics of the whole source and target image
    - Affecting the whole image
    - Needing segmentation for local image recoloring

Fig. 1. (a) the effect of total image recoloring using the method of Reinhard et al. (b) Partial image recoloring with an image fragment using the proposed method
– Method based on Basic Color Categories
  • Limitation in variation of color changing
    – Replaced only by a color from the same color category
    – Not changing blue to red

– Image palette association
  • Using complex image spatial or color characteristics to determining image palette

– Image color segmentation using expectation maximization method
  • Automatic segmentation and region color decision
  • Not always desirable results
– Color map lattice

• Cellular automata to select an object of interest
  – Single color is used as color source
  – Uniform recoloring when some variability of color shade is desired
Local color transfer

◆ Proposed method
  – To correct color of an object on a target image selected by user
    • Object is selected by color range and color statistics
      – Not precisely have to select the object by shape using segmentation or manual mode
    • Color influence map (CIM)
      – Target image’s CIM
      – Mask that specifies what parts of the target image will be affected according to the selected color range
    • Recoloring the target image
      – Modified version of the Color Transfer algorithm
– Calculating object’s color statistics
  • Selecting an object to correct a color at the target image
    – Loosely selecting a rectangular region
      » Using color range without spatial characteristics
      » Limitation such that the whole region must be inside this object

Fig. 2. The region is selected to correct the sky
• Color statistics
  – Suitable color space for color transformation
    » Small correlation between the axes in \( l\alpha\beta \) color space
  – mean
    \[
    \mu^R_c = \frac{1}{N_R} \sum_{i=i_1}^{i_2} \sum_{j=j_1}^{j_2} c(i, j) 
    \]
    \[ (1) \]
  – Standard deviation
    \[
    \sigma^R_c = \sqrt{\frac{1}{N_R - 1} \sum_{i=i_1}^{i_2} \sum_{j=j_1}^{j_2} \left( c(i, j) - \mu^R_c \right)^2} 
    \]
    \[ (2) \]

where \( N_R = (i_2 - i_1 + 1) \cdot (j_2 - j_1 + 1) \) is the number of pixels in the selected region \( R \), \( l \leq i_1 < i_2 \leq H \) and \( l \leq j_1 < j_2 \leq W \) define the rectangular region \( R \) and \( c(i, j) \) is a processed color channel of pixel \((i, j)\).
– Building the color influence map
  • Weight for color transfer for each pixel of the target image
    – Determined from its proximity to the color range
      » Mahalanobis distance between the pixel and the center of the color distribution
      » Euclidian distance for the decorrelated axes

\[
\rho(x, \mu) = \|x - \mu^R\|_E
\]  

(3)

where \( x \) is a color vector in working color space and \( \mu^R = (\mu_i^R, \mu_\alpha^R, \mu_\beta^R) \) obtained from (1).

\[
f_{ij} = F\left(\rho\left(\mu^R, c(i, j)\right)\right)
\]  

(4)

where \( c(i, j) \) is a color vector, \( \rho\left(\mu^R, c(i, j)\right) \) is obtained from (3), \( F(x) \) is defined at \([0, \infty]\) and \( \lim_{x \to \infty} F(x) = 0, \quad F(0) = 1 \).
• Function in color influence map
  – Various function and not strictly defined
  – Result of experiment for photograph of good enough quality

\[ F(x) = \frac{1}{e^{3x^2}} \]  

(5)

**Fig. 3.** CIM for the selected region from Fig. 2 using (5).
– Color transfer

• Target image recoloring according to the prepared CIM
  – Applying all the pixel of target image for each color channel separately with color statistics

\[
    c_{t\text{new}}^{i,j} = \mu_s + \frac{\sigma_s}{\sigma_t} (c_{i,j} - \mu_t) \tag{6}
\]

where the source data are marked with index s and the target data are marked with index t

\[
    c_{t\text{new}}^{i,j} = c_{t}^{i,j} + f_{ij} \left( \mu_c^{R_s} + \frac{\sigma_c^{R_s}}{\sigma_c^{R_t}} (c_{t}^{i,j} - \mu_c^{R_t}) - c_{t}^{i,j} \right) \tag{7}
\]

\[
    i = 1, H_t, \quad j = 1, W_t
\]

where \( c_{t\text{new}}^{i,j}, c_{t}^{i,j} \) are new and old value of a color channel of pixel \((i, j)\) of the target image respectively, \( \mu_c^{R_s}, \mu_c^{R_t} \) are taken from (1), \( \sigma_c^{R_s}, \sigma_c^{R_t} \) are taken from (2), \( f_{ij} \) is taken from (4), \( H_t \) is the target image height, \( W_t \) is target image width.
• Single color transfer

\[ c_t^{\text{new}}(i, j) = c(i, j) + f_{ij} \left( \text{Col}_c - \mu_c^{R_t} \right) \]

\[ i = 1, H_t, \quad j = 1, W_t \]

where \( \text{Col} \) is used as the source for recoloring.

Fig. 4. Partial image recoloring with a single color used as color source.
Results

- Test of the proposed algorithm
  - Three cases experiment
    - Using an image fragment or a single color as color source
    - Correction of both luminance and chrominance or chrominance only
    - Using an image of similar or different composition for the case of using an image fragment as color source
Important feature of the proposed algorithm

- Saving natural look of the image
  - Weights structure of image’s CIM
- Preserving high speed of image processing
  - Low computational complexity
Fig. 5. Partial image recoloring using images of different composition; separate areas recolored.

Fig. 6. Skin color correction at a portrait. The model looks tanned at the result image.
Proposed method

- Simple and fast algorithm for partial image recoloring
  - Allows user to correct an object of interest at an image
    saving one from the trouble of selecting it precisely
    - Preserving other color intact
    - Achieving natural look of the result for wide variety of input images