COLOR TRANSFER BETWEEN IMAGES

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Abstract

One of the methods to transfer the image’s color characteristics from one image to another image is to use a simple statistical analysis. The goal of this project is to provide a method to transfer the color from one image (Source image) to another image (Target image). We first transfer color in RGB from a source image to a target image. We use a simple statistical analysis by using mean shifting from the data points of the source image and using the standard deviation to scale data points of the source image to adjust the shape distribution to be close to the shape of the target image.

In this work, we compare the method between transferring in RGB space and in $\alpha\beta l$ space. We convert RGB space color to $\alpha\beta l$ space and use mean and standard deviations to adjust the color distributions in $\alpha\beta l$ space.

The image results in RGB space is different from the image transferred in $\alpha\beta l$ space. Because in RGB space, there is a correlation between R, G and B channel. From the work by Ruderman et al. developed a color space, called $\alpha\beta l$ space, which minimizes correlation between channels. The space based on data-driven human perception research that assumes the human visual system. So if we make transfer color in $\alpha\beta l$ space. The resulting color will have less correlation between channels and produce more appealing image.

Motivation in research topic

Reference with Reinhard et al 2001: Color transfer between images Wyszecki and stiles 1982: Color science, Concepts and Method. I have interested in image processing and computer graphic of this research. So that I would like to know how we can prove and what is a basically concept method that use in a step process transfer a color from a source image to another image by this theory and moreover, in the digital world, we can creativity and apply a simple statistical analysis to using in this research. I have expected will be a new feature plug in on a camera including all in a media technology.

With the rapid change of the digital world, everything around us that relates a digital media technology. Many industries try to research and adapt a new technology in a real product.

1. Introduction

This article will be describe the method how we can use a simple statistical mathematic to transfer a color from one is source image to a target image.

- One of the method to transfer the image’s color characteristics from a one image to another Image using a simple statistical analysis.

- The purpose of this part is to implement a simple algorithm that transfers the colors of one image onto another image.

- Automatically color transfer to produce a completely image.

- To make a synthetic image from the transfer color method.

We first manipulate RGB image which a method to converting RGB signals to Ruderman et al.’s perception-based color space $\alpha\beta l$. We compare a picture between a transfer an image in RGB space and $\alpha\beta l$ space. Also, we going to a steps to transfer and separate all transfer color method in RGB space and $\alpha\beta l$ space on this work.
1.1. The problem of Color Transfer Between Images

We use a simple statistical analysis concept in “Color Transfer between Images” project’s topic. That how can we applied a simple concept and implement on this project.

- How to transfer the image’s color characteristics from one image onto another one image?

Figure 1.1 source image

Figure 1.2 target image

Figure 1.3

Figures 1.4

Figure 1.5 result

2. Scope

Our goal, first begin with a transfer color in RGB space compare with the transfer color in \( \ell_{ab} \) space. We have separate 2 steps on this work following as:

2.1 Transfer color in RGB Space.

In color transfer image, one method using transfer a color we begin with specific a source image and target image, then we calculate a statistical in mathematic by using Mean and Standard deviations of both images.

This method will shift data point of a source image and show on a center space after then we make scale color distribution in RGB space of a source image before transfer a color into a target image. We will got a result as a target image that have a source image’s characteristics.

2.1.1 Specific source image

We need to specific a source image is a source that we use transfer into a target image.

Figure 2.2 Show a specific of source image.

(a) Show a source image that we use in a test.

(b) Show a color distribution in RGB space.
An example of a source image we are choose a cartoon picture, is one of a cartoon animation story by PIXXA that we use this source image into a target image.

2.1.2 Specific target image
Choose a target image that we need borrow a color from a source image.

![Image](a) ![Image](b)

Figure 2.3 Show specific target image.
(a) : Show a target image that we choose is a trees in green tone.
(b) : Show a distribution of a target image in RGB space.

2.1.3 Calculate mean and Standard deviations of Source Image and Target Image.

Mean:
\[
\bar{R} = \frac{\sum R_i}{n} \\
\bar{G} = \frac{\sum G_i}{n} \\
\bar{B} = \frac{\sum B_i}{n}
\]

\(R_i\) = Red color each pixel of picture

\(G_i\) = Green color each pixel of picture

\(B_i\) = Blue color each pixel of picture

Standard deviations:
\[
\sigma^R_s = \sqrt{\frac{\sum (R_i - \bar{R})^2}{n-1}} \\
\sigma^G_s = \sqrt{\frac{\sum (G_i - \bar{G})^2}{n-1}} \\
\sigma^B_s = \sqrt{\frac{\sum (B_i - \bar{B})^2}{n-1}}
\]

\[
\sigma^R_t = \sqrt{\frac{\sum (R_i - \bar{R})^2}{n-1}} \\
\sigma^G_t = \sqrt{\frac{\sum (G_i - \bar{G})^2}{n-1}} \\
\sigma^B_t = \sqrt{\frac{\sum (B_i - \bar{B})^2}{n-1}}
\]

![Figure 2.4](a)

Figure 2.4 Show a shift data point of source image in center space.
\[R' = R - \bar{R}\]
\[G' = G - \bar{G}\]
\[B' = B - \bar{B}\]

2.1.5 Scale data point of source image.

\[
R'' = \frac{\sigma^R_s}{\sigma^R_t} R'
\]
\[
G'' = \frac{\sigma^G_s}{\sigma^G_t} G'
\]
\[
B'' = \frac{\sigma^B_s}{\sigma^B_t} B'
\]

![Figure 2.5](a)

Figure 2.5 Show of a scale data point of source image in RGB space.

This step we scale data point of source image that show a shape nearly a target’s shape image before we transfer color on the 2.1.6 step.
2.1.6 Color transfer between images in RGB space.

\[
\begin{align*}
R'''' &= R''+R_i, \\
G'''' &= G''+G_i, \\
B'''' &= B''+B_i,
\end{align*}
\]

Figure 2.6 Show difference color distribution between a result of transfer color and target image.
(a) : A color distributions after transfer color from source image into target image.
(b) : A color distributions of a target image.

2.7 Result picture

Figure 2.7 Show a result of transfer color from source image into target image in RGB space.
(a) Source image (b) Target image (c) Result

Figure 2.8 Show a color distributions in a result

3. Transfer color in \( \ell \alpha \beta \) Space.

3.1. Specific source image
The first step we need to specific a source image that we would like transfer a color into a target image.

Figure 3.1 Transfer color in \( \ell \alpha \beta \) Space.

(a) Source image (b) Color distribution of source image
3.2 Specific target image

Figure 3.3 Show a target image and color distribution in $\ell \alpha \beta$ space.
(a) Target image (b) Color distribution of target image

3.3 Conversion RGB space to $\ell \alpha \beta$ space.

3.3.1 Conversion RGB space to LMS space.

$$
\begin{bmatrix}
L \\
M \\
S
\end{bmatrix} =
\begin{bmatrix}
0.3811 & 0.5783 & 0.0402 \\
0.1967 & 0.7244 & 0.0782 \\
0.0241 & 0.1288 & 0.8444
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B
\end{bmatrix}
$$

3.3.2 Conversion LMS space to $\ell \alpha \beta$ space.
Logarithmic space:

$$
\begin{bmatrix}
\ell \\
\alpha \\
\beta
\end{bmatrix} =
\begin{bmatrix}
\frac{1}{\sqrt{3}} & 0 & 0 \\
0 & \frac{1}{\sqrt{6}} & 0 \\
0 & 0 & \frac{1}{\sqrt{2}}
\end{bmatrix}
\begin{bmatrix}
L_{\log} \\
M_{\log} \\
S_{\log}
\end{bmatrix}
$$

3.4 Calculate mean and Standard deviations of Source image and Target image.

Calculate mean in $\ell \alpha \beta$ space:

$$
\bar{l} = \frac{1}{n} \sum_{i=1}^{n} l_i \\
\bar{\alpha} = \frac{1}{n} \sum_{i=1}^{n} \alpha_i \\
\bar{\beta} = \frac{1}{n} \sum_{i=1}^{n} \beta_i
$$

Standard deviations of target image

$$
\sigma_l = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (l_i - \bar{l})^2} \\
\sigma_\alpha = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (\alpha_i - \bar{\alpha})^2} \\
\sigma_\beta = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (\beta_i - \bar{\beta})^2}
$$

Standard deviations of source image

$$
\sigma_s = \sqrt{\frac{1}{n-1} \sum (l_i - \bar{l})^2} \\
\sigma_s^\alpha = \sqrt{\frac{1}{n-1} \sum (\alpha_i - \bar{\alpha})^2} \\
\sigma_s^\beta = \sqrt{\frac{1}{n-1} \sum (\beta_i - \bar{\beta})^2}
$$

3.5. Shift and Scale color distributions

3.5.1 Shift data point to center space

$$
\ell' = l - \bar{l}_s \\
\alpha' = \alpha - \bar{\alpha}_s \\
\beta' = \beta - \bar{\beta}_s
$$

Figure 3.4 Show a color distributions after shift to center space.

3.5.2 Scale data point of Target Image.

$$
\ell'' = \frac{\sigma_l}{\sigma_s} \ell' \\
\alpha'' = \frac{\sigma_\alpha}{\sigma_s^\alpha} \alpha' \\
\beta'' = \frac{\sigma_\beta}{\sigma_s^\beta} \beta'
$$
3.5. Show a scale color data of target image

3.6. Color transfer between Images.

\[ I'' = I'' + \bar{I}, \]
\[ \alpha'' = \alpha'' + \bar{\alpha}, \]
\[ \beta'' = \beta'' + \bar{\beta}, \]

3.7. Conversion \( \ell \alpha \beta \) space to RGB space.

3.7.1. Conversion \( \ell \alpha \beta \) space to RGB space.

\[
\begin{bmatrix}
L_{\text{exp}} \\
M_{\text{exp}} \\
S_{\text{exp}}
\end{bmatrix} =
\begin{bmatrix}
1 & 1 & 1 \\
1 & 1 & -1 \\
1 & -2 & 0
\end{bmatrix}
\begin{bmatrix}
\frac{\sqrt{3}}{3} & 0 & 0 \\
0 & \frac{\sqrt{6}}{6} & 0 \\
0 & 0 & \frac{\sqrt{2}}{2}
\end{bmatrix}
\begin{bmatrix}
\ell_{\text{back}} \\
\alpha_{\text{back}} \\
\beta_{\text{back}}
\end{bmatrix}
\]

3.7.2. Conversion LMS space to RGB space

\[
\begin{bmatrix}
R_{\text{new}} \\
G_{\text{new}} \\
B_{\text{new}}
\end{bmatrix} =
\begin{bmatrix}
4.4679 & -3.5873 & 0.1193 \\
-1.2186 & 2.3809 & -0.1624 \\
0.0497 & -0.2439 & 1.2045
\end{bmatrix}
\begin{bmatrix}
L_{\text{exp}} \\
M_{\text{exp}} \\
S_{\text{exp}}
\end{bmatrix}
\]

3.8. Result picture

(a) Source image (b) Target image (c) Result

Figure 3.8 Show a color distributions in a result picture
4 Implementation
We develop this work using a MATLAB version 7.0.4 that we design a program interface easy to use, we are separate for user select input source image and target image and need user click a button transfer color manipulation in RGB space and $\ell\alpha\beta$ space. We will got a result all both method on this program.

Computer
- CPU: Intel® Pentium® 4 2.80 GHz
- RAM: DDR 256 MB
- MAINBOARD: Asus PS333
- HARD DISK: 40 GB
- MOUSE

Software
- MAIN PROGRAM: MATLAB 7.0.4
- SUPPORT PROGRAM: Photoshop

5 Discussion & conclusion
After we finished a transfer color, we pursue the image results in RGB space is different from the image transferred in $\ell\alpha\beta$ space. Because in RGB space, and then is a correlation between R, G and B channel. From the work by Ruderman et al. developed a color space, called $\ell\alpha\beta$ space, which minimizes correlation between channels. The space based on data-driven human perception research that assumes the human visual system. So if we make transfer color in $\ell\alpha\beta$ space. The resulting color will have less correlation between channels and produce more appealing image.

- A method to transfer the color from one image’s color characteristics to another one.
- The image result from transfer color in $\ell\alpha\beta$ space gives the better than transfer color in RGB space.
- Automatic color transfer technique
  This work is a automatic color transfer technique after we select a source image and target image the transfer color method will automate.
- Need more interaction
  This work show of result that we can not expected a result, so that need more interaction and we can mark only point that need a transfer method.

5. Future work
Colorization using Optimization A. Levin, D.Lischinski, Y.Weiss

(a) Marked B/W image
(b) Result

Figure 4.1
Show program’s interface using on this work.

Figure 5.1 Show a Colorization using Optimization
(a) Mark image is a source image (b) Result of image after pass a mark color process method
Figure 5.2 Show a Colorization using Optimization

(a) Input image  (b) An image with mark image

6 References


