Color Transformation Based on the Basic Color Categories of a Painting

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1 Introduction

Each painter renders a painting in her own style. This style can be distinguished by looking at elements such as motif, color, shape deformation and texture. Previously, [Hertzmann et al. 2001] suggested a method for applying the texture of an image to a photograph. In this paper, we will focus on the element of "color".

Basically, color is applied depending on the subject motif. However, painters do not choose precisely the same color as that of the motif. Imagine an artist painting a forest. If she paints it in green-yellow, we may perceive the forest as being vivid. On the other hand, if she paints it in dark-olive-green, we may perceive it as being calm. In this way, by managing its saturation, brightness and hue, the artist can control viewer's perception of her painting. Consequently, we propose a method which applies the color features of a given painting to a photograph, in order to give a similar impression. [Reinhard et al. 2001] suggested a method whose goal is similar to ours, but our method is based on color categorization characteristics of human vision, and can do all processing automatically even if the two input images have no similarity in composition.

2 Color Transformation Technique

While humans have an outstanding ability to discriminate between colors, it is reported that human color vision can group similar colors into the same category[Berlin and Kay 1969]. The same source notes that in many languages, there are 11 basic color categories. In this paper, we assume that if a color is converted to another color within the same basic color category, the result will not cause much incongruity in human vision. Based on this assumption, our algorithm transforms colors according to the following process:

First, the algorithm calculates a distribution of pixel color values of a photograph in *CIE* $L^*a^*b^*$ color space. Then the color space is automatically segmented into 11 categories based on experimental results of the ratings of the basic color categories for each test color[Uchikawa et al. 1994]. After that, convex hull ch_i for color $i(i = 1,..,11)$ are generated for each category. The convex hulls ch'_i for the painting are generated in a similar manner.

Next, for every pixel color value of the photograph, the algorithm finds its corresponding color in the reference painting. For a pixel color value p in ch_t of the photograph, its corresponding color value p' is given by:

$$p' = \frac{Distance(c_t, p)}{Distance(c_t, b)}(b' - c'_t) + c'_t \qquad (1)$$

where c_t and c'_t are the center of gravity of ch_t and ch'_t respectively, b is the intersection point between ch_t and a line which start at c_t and goes through p, b' is the intersection point between ch'_t and a line which start at c'_t and whose direction is from c_t to p.

By substituting each pixel color value with its corresponding color in the reference painting, we can produce an image whose color features are similar to those of the reference painting.

3 Result and Discussion

Figure 1 shows an example of our color transformation algorithm. Figure 1(a) shows a target photograph, 1(b) shows a reference painting, and 1(c) is the color-transformed image resulting from (a). Because our algorithm calculates a matching color point for every image pixel instead of substituting each segmented area to one focal color, the clouds and leaves preserve their color variety. Furthermore, because each pixel remains in the same color category after conversion, we realize color transformation without any sense of incongruity in spite of a large transformation of color.

In our future work, we will consider the use of white balance adjustment, the color transformation of a pixel whose color category is not present in the reference painting, and color gradation which covers two color categories.

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The reference image is from *Mark Harden's Artchive*.

References

BERLIN, B., AND KAY, P. 1969. *Basic Color Terms: Their Universality and Evolution*. University of California Press.

HERTZMANN, A., JACOBS, C. E., OLIVER, N., CURLESS, B., AND SALESIN, D. H. 2001. Image analogies. In *SIGGRAPH2001 Proceedings*, ACM, 327–340.

REINHARD, E., ASHIKHMIN, M., GOOCH, B., AND SHIRLEY, P. 2001. Color transfer between images. In *Computer Graphics and Applications*, IEEE, 34–41.

UCHIKAWA, K., KURIKI, I., AND SHINODA, H. 1994. Expression of color appearance in aperture and surface color modes with a category rating estimation method. *J. Illum. Engng. Inst. Jpn 78*, 2, 41–51.

Figure1 : **(a) target photograph** **(b) reference painting** **(c) result image**