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Wilfried Philips (Eds.)

Computer Vision/ Computer Graphics Collaboration Techniques

Third International Conference, MIRAGE 2007
Rocquencourt, France, March 2007
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Preface

This volume contains the papers accepted for presentation at MIRAGE 2007.

The Mirage conference is becoming recognized internationally, with presentations coming from 31 countries. South Korea proved to be the most active scientifically with a total of 73 submitted papers, far above China (27 submitted papers), Taiwan (10) and India (9), which proves the strong domination of Asia in the development of this new technology.

We received a total of 198 submissions. Reviewing was very selective as the Program Committee accepted only 42 oral presentations and 17 posters. We had to extend the conference period from two to three days, as the number of submissions was mutiplied by three compared to the previous conference, which proves that this conference attracts more and more researchers. All papers were reviewed by two to four members of the Program Committee. The final selection was carried out by the Conference Chairs.

We wish to thank the Program Committee and additional referees for their timely and high-quality reviews. We also thank the invited speakers Peter Eisert and Adrian Hilton for kindly accepting to present very interesting talks.

Mirage 2007 was organized by INRIA Rocquencourt and took place at INRIA, Rocquencourt, close to Versailles Castle. We believe that the conference proved to be a stimulating experience, and we hope readers will enjoy these proceedings.

January 2007

A. Gagalowicz
W. Philips

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Published Papers

An Improved Color Mood Blending Between Images Via Fuzzy Relationship

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Abstract. This paper presents an improved color mood blending between images via fuzzy relationship. We take into consideration the weighted influences of the source as well as the target image. Our algorithm automatically calculates the weights according to the fuzzy relations of images with Gaussian Membership Function, derived from both the statistical features of the source and target image. As the experimental results shown, the visual appearance of the resulting image is more natural and vivid. Our algorithm can offer users another selection for perfecting their work. It has four advantages. First, it is a general approach where previous methods are special cases of our method. Second, it produces a new style and feature. Third, the quality of the resultant image is visually plausible. Finally, it is simple and efficient, with no need to generate swatches.

1 Introduction

In daily life, each object we see or touch has a set of colors to describe it. When the object's colors are reflected into our vision system and the color information is sent to the cerebrum, our cerebrum tells us what the color is. Due to the complex architecture of the cerebrum, our vision is sensitive to colors even if there is only a subtle change in hue. In addition, everyone has different tastes and experiences that affect their perception and identification of colors. For example, we commonly use a vivid green to represent spring and summer. Winter is described by white or silver gray. Moreover, everyone has different reactions to colors and even some perceptual differences, which can affect their responses.

Since colors are ubiquitous and crucial for human perception, the transformation of color features is very important for digital image processing. Reinhard et al. proposed an algorithm to apply the colors of one image to another [10], attempting to make the colors of the source image look more like that of the target image. Their algorithm is simple and effective and the result is impressive. Thereafter, many varied techniques have been presented to achieve the same goal of color transfer. In addition, Welsh et al. [16] and Chen et al. [6] extended Reinhard's work to coloring grayscale images.

As mentioned in [10], given two suitable images for producing a pleasing result, the color distributions of two given images should be similar. Otherwise it may produce a grotesque and unnatural result. Such phenomena occur because the relation of

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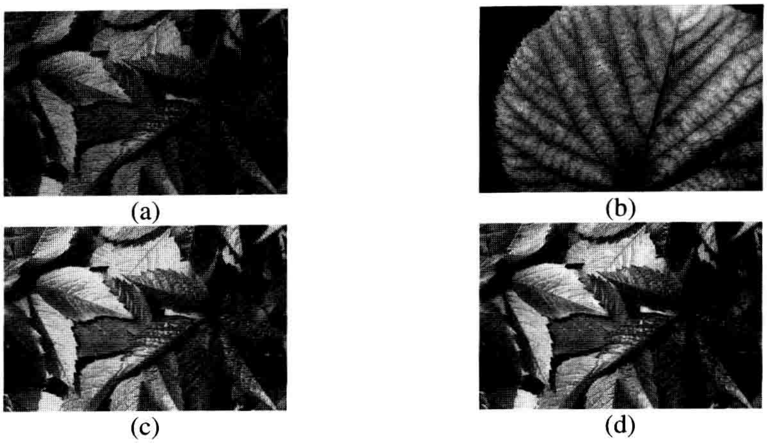

Fig. 1. Leaves. (a) is the source image and (b) is the target image. (c) is the result produced by using Reinhard's method [10]. Their work only takes into consideration the colors of the target image, attempting to make the color appearance of the source image look more like that of the target image. We extend Reinhard's work, and consider the influence of both source and target images, blending colors of both images via their fuzzy relationship with Gaussian Membership Function, as shown in (d). The visual appearance of the resulting image is more natural and vivid, producing a new style.

color distribution between two given images are not taken into consideration. For this reason, we think that color transfer should not only involve the target image's color features. It should also include some color characteristics of the source image. A simple linear interpolation method is $Rc = \alpha Sc + (1\text{-}\alpha)Tc$, where *Rc*, *Sc*, and *Tc* respectively indicate the resultant, source, and target images' colors; α and $(1\text{-}\alpha)$ determine the degrees of source and target image colors transferred. However, as mentioned above, two suitable images must be given to produce a pleasing result by using Reinhard's work [10]. This implies that when the transformation is manipulated the relationship between the two given images should be taken into consideration. As a result, the immediate linear interpolation method is insufficient.

In [15], two user parameters are introduced to attempt to yield a natural and reasonable result, in which the idea is similar to [11]. Even though this operates well, it is still not convenient to use due to the manually adjustment of those two parameters. The relation between images is not taken into account in their work. As a result, we design an automatic way to form an improved color transfer operation based on the relationship between images, resulting in color blending effects. To achieve this goal, in this paper, we are interested in devising an efficient method to provide users another choice for color transfer. Therefore, based on the previous work [10], a new transformation scheme is defined as Eq. (1) in which two parameters, l and m, are individually calculated depending on the fuzzy relation between given images with a Gaussian Membership Function. As the experimental results in Fig. 1, show, our algorithm produces a new style.

We review related work in Section 2 and describe our algorithm in Section 3. We demonstrate results and exhibit those produced by Reinhard's original method in Section 4. The conclusion and future work are given in the final section.

2 Related Works

The initial paper on color transfer between images was proposed by Reinhard et al. [10]. A number of similar papers were then presented [2-5, 13], some of them intending to colorize grayscale images [6, 7, 13, 16, 19], while others intended to improve the efficiency of the colorization [9, 18].

The color transfer algorithm proposed by Reinhard et al. provides an easy and effective approach to transfer color characteristics from the target image to the source image. The operation employs a de-correlation color space $l\alpha\beta$ which was developed by Ruderman [12] for transferring colors. The l channel corresponds to an achromatic luminance channel, and α as well as β channels separately correspond to the yellow-blue and red-green opponent channels. Reinhard et al. did color transformation using a simple statistical method which involves scaling and shifting calculations. Their method performs well. No artistic talent is required, and the outcome is impressive. However, their method may sometimes produce unnatural results where the source and target images do not match as shown in Fig. 4(c). The result reveals an unnatural appearance, which is particularly prominent when the source and target images are unsuitable, either in luminance or in color aspects. To solve this drawback, Reinhard et al. further presented a swatch approach. However, a user has to first generate swatches, and then manually determine swatch pairs to perform the color transfer. As a result, their method requires much user intervention when an unnatural appearance is produced.

Recently, Chang et al. presented an alternative method to deliver the colors from the target image to the source image [2-5]. The method relies on only transferring similar colors between source and target images. It does not catch image colors entirely, but catches some color features for each color unit. A color unit is a perceptually agreeable color category. In their work, they provided eleven basic color categories which were developed by Berlin and Kay [1]. Then, according to psycho-physiological experiments, they transform the relational colors between images and the results are natural and attractive. Unfortunately, their algorithm is not efficient because each pixel value has to be classified into one of the basic color categories before the color transfer. Moreover, their algorithm is limited, since it transfers colors within the same color categories, regardless of possible cross-category color transfer. In addition, if a pixel in the source image has no corresponding colors in the target image, their algorithm needs extra computations to estimate suitable color distributions for transferring such a pixel. Other extra computations are needed for eliminating the pseudo-contour artifacts which occurs at the boundary between two colors.

Based upon Reinhard et al.'s work, Wang et al. generated an image sequence for simulating the atmospheric variations of a scene [14, 15]. In their framework, four images, one simulated source image and three different atmospheric target images are used, and then two statistical values, the mean and the variance, are separately computed in the de-correlation color space [12]. The mean and variance used for image transfer in an image sequence are then interpolated with a color variation curve (CVC) to produce in-between color transfers. The algorithm can produce an image sequence using color mood variation and generates visually plausible effects.

3 Proposed Algorithm

We think that color transfer should involve not only the color characteristics of the target image but also those of the source image. This will allow us to balance the influence between two images, which will result in the appearances of color mood blending. Balance is particularly important when the target image has many abnormal characteristics, such as low luminance, or has a very limited color spectrum. Based on the above concept, different transformation weights should exist for the source and target images in color manipulation. As a result, we define a formula as expressed in Eq. (1),

$$B_i = \frac{\sigma_t}{\sigma_s}(S_i - \mu_s) + l\mu_t + m\mu_s, \tag{1}$$

where B_i is the i^{th} blended pixel, S_i is the i^{th} pixel in source image, and l and m represent the transformation weights. μ_s and μ_t are the means and σ_s and σ_t are the standard deviations, respectively, where s indicates the source image and t indicates the target image. Clearly, we need to calculate the relations of the transformation weights, l and m. We first express the mean value of the blended result, as shown in Eq. (2).

$$\mu_{new} = \frac{1}{n}\sum_{i=1}^{n} B_i = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{\sigma_t}{\sigma_s}(S_i - \mu_s) + l\mu_t + m\mu_s\right) \tag{2}$$

In [8], Gaussian Membership Function, Eq. (3), has the ability to measure the distributions of two data sets to interpret their fuzzy relationship. F indicates the degree of similarity between the two data sets.

$$F = exp\left[-\left(\frac{\mu_s - \mu_t}{\sigma_s + \sigma_t}\right)^2\right] \tag{3}$$

We refer to such a fuzzy value as *matching value*. A large matching value, which is close to one, means that the source and target images are compatible as indicated by the similar mean values. This leads to the final blending result which appears similar to the source image. Note that σ_t and μ_t do not change during the transformation. Now,