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Improved Posterized Color Images based on Color Quantization and Contrast Enhancement

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***Abstract*—**A conventional image posterization method occasionally fails to preserve the shape and color of objects due to the uneffective color reduction. This paper proposes a new image posterizartion method by using modified color quantization for preserving the shape and color of objects and color contrast enhancement for improving lightness contrast and saturation. Experiment results show that our proposed method can provide visually more satisfactory posterization result than that of the conventional method.

***Keywords*—**Color contrast enhancement, color quantization, color segmentation, image posterization

I. Introduction

A POSTER is used for many purposes such as advertisement, propaganda, and education. It is designed to be eye-catching and to convey information. For this purpose, it usually simplifies an object as much as possible and uses colors easily appealing to people. When a color image is given, to automatically create a poster image from it can be an interesting topic in color image processing, and is called image posterization, which entails a process of reducing the number of color used, since posters often use small number of vivid colors to draw human attention. Image posterization can also create an artistic effect and has been implemented in most photo-editing softwares.

As an image posterization method, we can find some commercial photographic tools [1], [2]. Its algorithm generates a combination of values dividing a histogram of each channel at a regular interval in RGB color space [3]. We can find that the algorithm is simple, their execution time is very fast, and its result image has strong color contrast. Yet it is also found that as the number of colors used gets smaller, the shapes of some objects are not well preserved and some colors change too much due to too simple nature of the algorithm. And it often generates some colors, which will not be used in the posterized image, because there is a chance that some part of the image histogram may be empty.

Therefore, we suggest a new image posterization method based on effective color quantization and color contrast enhancement. Firstly, to reduce effectively the number of color, we use and modify the existing color quantization method [4], because it enables us to control a ratio of the lightness to the chromaticity when calculating color difference. For posters, strong color contrast of a quantized image is preferable, so we need to adjust the lightness and saturation contrasts, respectively. We then switch from CIELUV color space to HSV color space, because the lightness and saturation can be separated here. We first enhance global lightness contrast by stretching lightness. And then, we use a sigmoid function [9] to achieve local lightness contrast enhancement. Finally, saturation contrast is enhanced by maximizing the saturation value in order to obtain more vivid colors. We can generate improved poster images that keep the objects and colors well through the color quantization and overall color contrast enhancement.

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II. Related Work and Proposed Method

A. Conventional Image Posterization Method

When RGB values are given, new R′G′B′ values are calculated by an image posterization algorithm and in this case, the number of color in the output image is usually very small compared to original one. Currently, some commercial photographic tools have already supported an image posterization algorithm [3]. This method firstly receives posterized level N_p (≥2) from a user and determines a representative RGB values in each histogram, respectively, finally producing a poster image in the combination of these colors. If quantized level N_p is given, the number of possible color would be N_p^3 colors. Here, N_p levels mean that each span of RGB channels is divided into N_p regions, respectively. Assume that an input value from a channel is x. The next step is to assign x into one of N_p regions. Now, we first introduce region size defined by

$$S_r = 256/N_p. \quad (1)$$

Now, i-th region will be chosen by

$$i = \left\lfloor \frac{x}{S_r} \right\rfloor, \qquad i = 0,..., N_p - 1. \quad (2)$$

All the values inside each region will be replaced by its representative value y_i, which is defined by

$$y_i = \lfloor i\Delta_r \rfloor, \qquad i = 0,..., N_p - 1, \quad (3)$$

Here, Δ_r is an output level difference and is given by

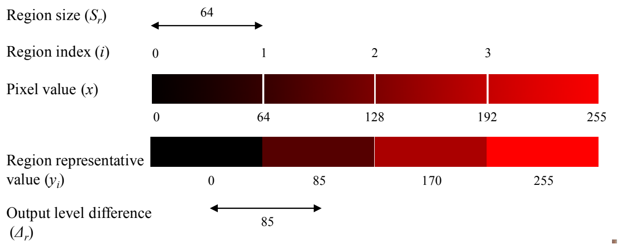


Fig. 1 Example of determining representative value (N_p=4) from a histogram

$$y_i = \lfloor i\Delta_r \rfloor, \qquad i = 0,\ldots, N_p - 1, \tag{4}$$

We note that $y_{i+1} - y_i \approx \lfloor \Delta_r \rfloor$. These steps are summarized in Fig. 1 when N_p=4.

The execution time of this method is fast, since its operation is quite simple and its result image shows strong color contrast, because the representative values include both 0 and 255. However, as the number of colors used gets smaller, the shapes of some objects in the result image are not well preserved and some colors change too much. The algorithm often generates some colors, which cannot be used in the postrization process. Besides, the number of color used in posterization is not arbitrary, but N_p^3 only. This seems to be rather a serious drawback of the algorithm.

B. Color Quantization Using Chromaticity Enhancement Factor

To obtain an arbitrary number of colors in posterization, we introduce color quantization which is a process that reduces the number of distinct colors used in an image. Much research on the color quantization method has been published [4]-[6]. We can choose any quantization method but we employ and modify one color quantization method [4] which can control the balance between the lightness and the chromaticity in the calculation of color difference. This method consists of five steps: First, RGB values of an input image are converted into CIELUV values, which can separate the lightness and chromaticity informations. Then, the number of color is reduced through adaptive uniform quantization. Next, the weighted color difference is obtained by using a lightness enhancement factor to put more weight to lightness than to chromaticity. The perceptual threshold is introduced to preserve some distinct colors that are significantly different from the surrounding colors. Finally, color quantization is performed using the merging algorithm with the new weighted color difference and the perceptual threshold.

A motivation of the modification is that when two objects with the same chromaticity are illuminated on the different lightness condition, two objects are perceived to have different colors. In another words, the perceived color is defined by lightness (L) as well as chromaticity (u, v). This phenomenon has been reported elsewhere [7], [8]. Accordingly, the above-mentioned quantization method [4] employed the weighted color difference formula to put more weight to lightness than to chromaticity. So this method could express well subtle color difference and obtain more natural results due to enhanced color expression of a quantized image. However, this idea is not suitable for image posterization, in which a very small number of colors is often used. When extremely low quantization level, a very small number of colors is allowed, an object with a single chromaticity is often quantized to more than two objects with different colors due to different lightness. In this case, the shape of an object appears to be broken or divided after image posterization. Therefore, because of this phenomenon, our posterization method introduces a new color difference formula, which uses a chromaticity enhancement factor (w) to put more weight to the chromaticity than to the lightness when calculating the color difference between the two points in CIELUV color space. The color difference formula is now modified by

$$(\Delta E^*_{uv})' = [w^2(\Delta L^*)^2 + (\Delta u^*)^2 + (\Delta v^*)^2]^{1/2}, \tag{5}$$

where w is a chromaticity enhancement factor and experimentally set to 0.4. Our proposed method is more successful in objects segmentation by reducing highlight and shadow effects within an object, resulting in improved ability to reproduce the color and shape more exactly.

C. Color Contrast Enhancement

Though color quantization can preserve the characteristic shape and color of an object, the resultant image cannot provide strong color contrast, which is preferable in a poster. The color contrast helps us to distinguish a color from other colors more easily. More specifically, there are hue, lightness, and saturation contrasts [10]. To manipulate these contrasts, we need switch from CIELUV color space to HSV color space [11], in which hue, saturation, and lightness information can be separated. Time needed in the conversion is very small because of the reduced number of colors though color quantization. HSV color space stands for hue (H) [0°, 360°], saturation (S) [0, 1], and lightness or value (V) [0, 1]. The next step is to improve the contrast by varying S and V components, because H value is already determined by the color quantization process.

To enhance the lightness contrast, we first stretch V component by normalization, which maps the minimum value of lightness ($V_{\min}$) to 0 and its maximum value ($V_{\max}$) to 1. This stretching function is defined as

$$V_s = (V_{in} - V_{\min})/(V_{\max} - V_{\min}). \tag{6}$$

Here, V_{in} is an input value of V and V_s is an output value of the stretching function. We have enhanced the global lightness contrast by stretching V values to have both 0 and 1 value. Then, we rescale V_s with a range (0,1) into V'_s with a range (-10, 10). For this, we use the following conversion formula.

$$V'_s = 20V_s - 10. \tag{7}$$

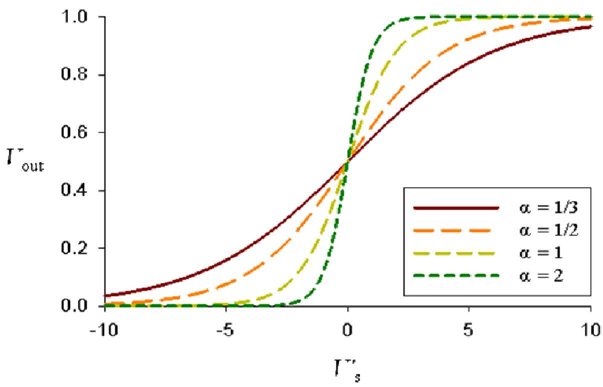


Fig. 2 Output of sigmoid function depending on slope factor (α)

Now, we apply a sigmoid function to V'_s values in order to adjust the local lightness contrast. Its function rearranges the distribution of V values, making low V value be lower, high V value be higher. This sigmoid function is a nonlinear function with slope factor α defined by

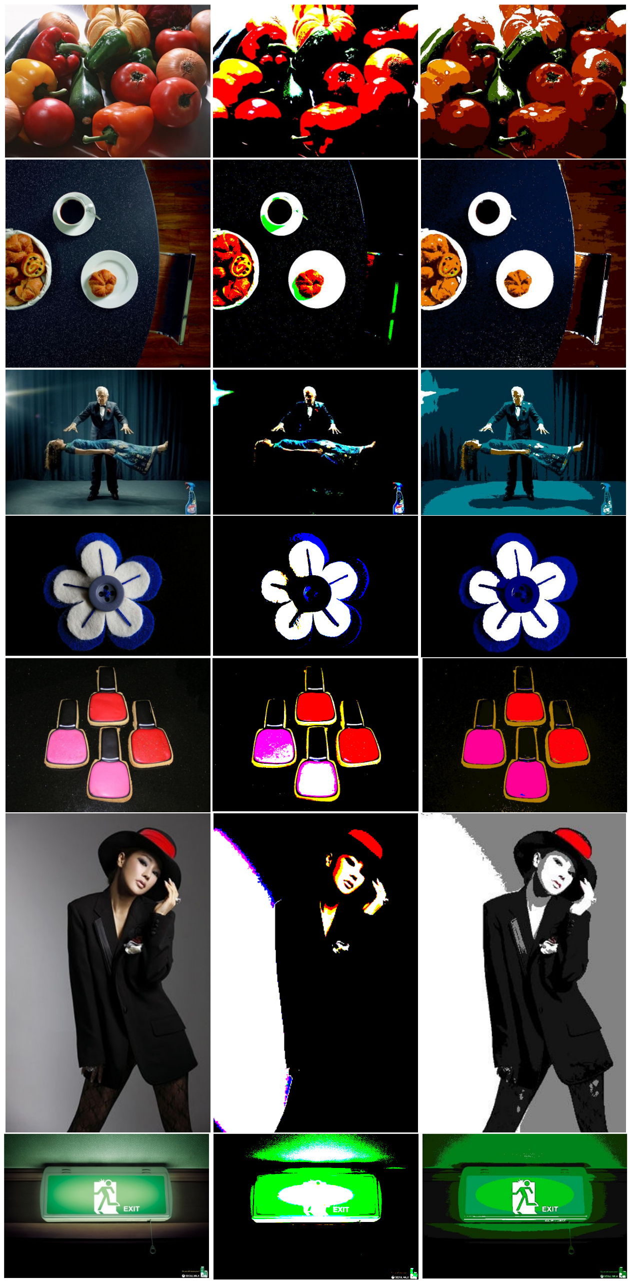
$$V_{out} = 1/(1 + e^{-\alpha V'_s}). \tag{8}$$

where V'_s and V_{out} are input and output values. Here, α determines the slope of the sigmoid function. If α=0, this is a step function. If α=∞, this is a linear function. In (8), we can adjust the local lightness contrast of the result image by changing α value, since the output shape of the sigmoid function depends on α, as is shown in Fig. 2.

Generally, high saturated colors tend to draw human attention and are often used in posters to make the posterized image have vivid colors. Thus, we obtain the high saturation by setting the S value to be 1. However, when low saturated colors are forced to be converted to high saturated colors, many colors are often perceived to change too much compared to original colors. So, in this case, the S value remains unchanged. Further study seems to be made to find reasonable or more preferable S values for a poster application.

III. Experimental Results and Discussions

The performance of the proposed method has been evaluated and compared to the method of the conventional photographic tool against about 30 color images gathered from the internet. All images are not good candidates for posterization, and thus we select images which have a small number of objects inside a relatively simple background. For the performance comparison of the convention method and our proposed method, seven sample images are posterized to 8 colors and shown in Fig. 3. The results of the convention method show that their results show very strong color contrast, but the characteristic shapes and colors of objects such as Vegetables, Table, Magician, Button, Rackets, Women, and Emergency exit are broken and part of objects is smeared into a background, as is shown in Fig. 3(b). On the other hand, when compared with Fig. 3(b), the results of our proposed method show that characteristic shapes and colors of these objects are well preserved as shown in Fig. 3(c). And the overall color contrast of the conventional method seems to be too high, while the local contrast of our proposed method becomes lower but still high enough to accentuate the theme objects. We also note that our proposed method tries to preserve the colors of an original image. For all these images, α is set to 0.3 and S to 1.



(a) (b) (c)

Fig. 3 Image posterization results with 8 colors for conventional method and proposed method. (a) original image (b) posterized image for conventional method (c) posterized image for proposed method (α=0 .7, S=1)

For evaluating how much the choice of the number of colors influences the posterization result, we select the Coffee table image as an example with 8, 27, and 64 colors for conventional

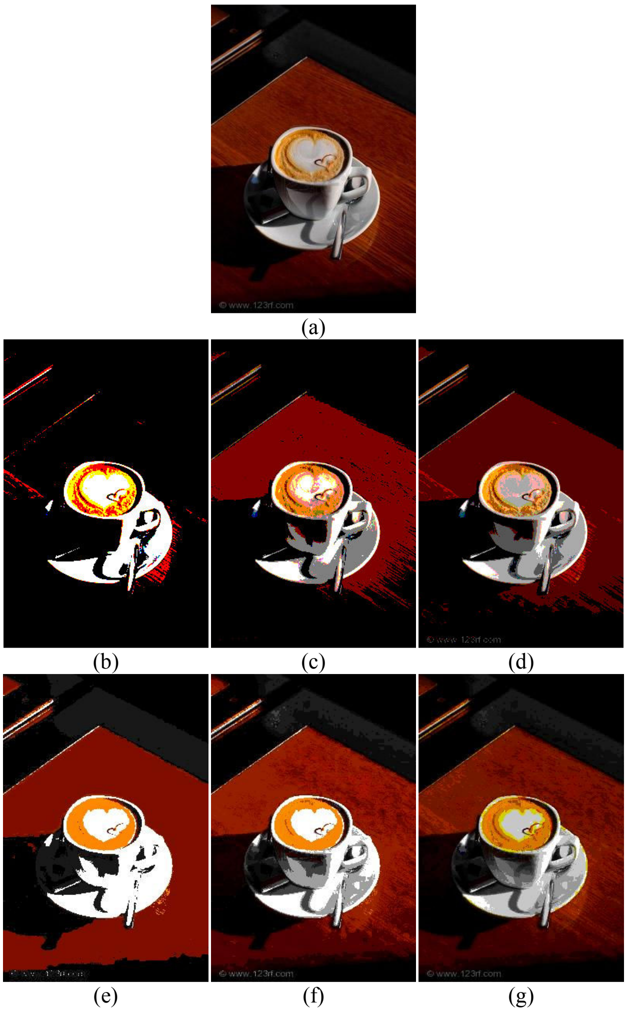


Fig. 4 Image posterization results with 8, 27, and 64 colors for conventional and proposed methods (α=0.3, S=1). (a) original image (b), (c), (d) posterized images with 8, 27, 64 colors by conventional method and (e), (f), (g) posterized image by proposed method

and proposed methods and show the results in Fig. 4. In case of 8 colors, the convention method does not preserve well the shapes and colors of Coffee table, but our proposed method is successful in objects segmentation. As the number of colors increases, both methods segment the cup successfully. However, in the convention method, colors of the table and the coffee as well as the heart shape do not remain constant. As for the proposed method, the colors of the table and the coffee remain almost unchanged and the heart shape inside coffee is well preserved.

Therefore, the experimental results show that our proposed method can preserve the characteristic shapes and colors quite well and still achieves strong color contrast that is required for posterization.

IV. Conclusion

New image posterizartion is presented using color quantization and color contrast enhancement. The proposed method modifies the existing color quantization method by applying a chromaticity enhancement factor to put more emphasis on the chromaticity and successfully extract the characteristic shapes and colors of objects. Lightness contrast is improved on HSV color space by the stretching algorithm and sigmoid function, while the saturation is enhanced by adjusting S value. Through experiments, we confirmed that our proposed method can preserve not only the shapes and colors of objects but also produce visually more satisfactory results by choosing the colors close to original ones.

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