Stained Glass Rendering for Images

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Abstract—A flexible stained-glass stylization system is proposed. It consists of three stages including image segmentation and color/texture allocation. The second stage provides some options for users to choose from.

The first stage is manual image segmentation. In the second step, each segmented region is allocated with the color or texture of reference images chosen from a database. The proposed system provides many options for this allocation, allowing the users to select from a variety of form of texture or color allocation.

The proposed system is easy to use and very flexible. It provides many options for users to stylize an image into a variety of stylized results. Our experiments show that the proposed system can generate a wide range of satisfactory results.

Keywords—image stylization, seed, segmentation, stained glass, Voronoi diagram.

I. INTRODUCTION

STAINED glass is a newly emerging style in image stylization [1]. The applications of image stylization are extensive in areas including entertainment, and interior design.

This study proposes an image stylization system for reforming a source image into a "stained glass" style or some other style desired by users. It consists of three stages: image segmentation, color or texture allocation, and synthesis of calmes.

The first step of image stylization is image segmentation. Different segmentation results yield various stylized results, including automatic segmentation [2, 3, 4], such as Voronoi diagram, semi-automatic segmentation, and automatic segmentation [1,5,6]. The proposed system uses an automatic segmentation scheme for its flexibility. After segmentation, the system allows users to allocate texture/color to each segmented region in a variety of versions of color/texture replacement. Experimental results show that our system is easy and flexible to manipulate and provides satisfactory stylization results.

II. THE PROPOSED STYLIZATION SYSTEM

A. Segmentation

For flexibility, the system allows users to perform manual segmentation using Adobe Photoshop CS4. Fig. 1 shows a result of this segmentation method.
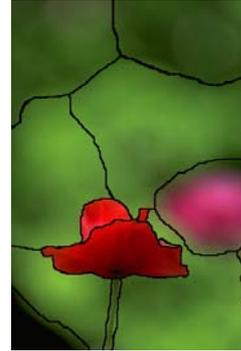
Fig. 1 Manual segmentation result

B. Color or Texture Allocation

After segmentation, the user can choose color or texture from a database of reference images to replace the images in any segmented region. Our system offers a variety of versions of color/texture replacement, described as follows.

C. Allocation 1:

First, a favorite region R of a reference image from the image database is chosen, whose color information is then allocated to a region T of the target image. Let T' be the texture-allocated image and $T_z'(x,y)$ be the allocated color in the z-channel of (x, y). Then, the allocation can be described by (1) [7], where $z \in \{l, a, b\}$, μ_T^z and μ_R^z are means, and σ_T^z and σ_R^z are are standard deviations of the z-channel in regions T and R, respectively, As a result, the resulting allocated region will have the same mean and standard deviation in each channel as those in the reference region. Fig. 2 shows an example of such allocation.

$$T_z^{'}(x, y) = \frac{\sigma_R^z}{\sigma_T^z}(T_z(x, y) - \mu_T^z) + \mu_R^z \qquad (1)$$

<center>(a) reference image   (b) result of color allocation</center>
<center>Fig. 2 Color allocation (Allocation 1)</center>
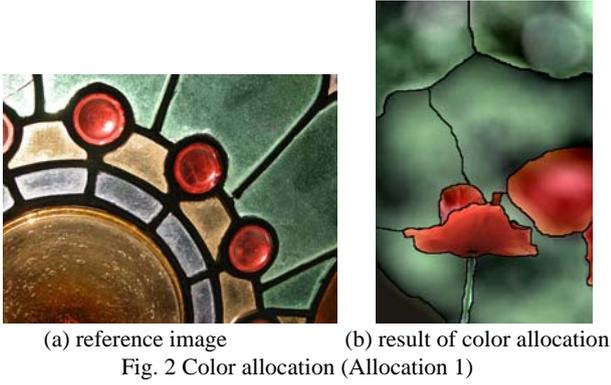
D. Allocation 2:

To allocate the texture of a reference region to a target region, first mark a pair of corresponding points (x_T, y_T) and (x_R, y_R) in the target region T and reference image R, respectively, and then allocate the luminance of the point (x', y') in R to the point (x, y) in T, where $(x', y') - (x_R, y_R) = (x, y) - (x_T, y_T)$, as shown in Fig. 3. A scale w could be added to adjust the texture size to create the new correspondence: $(x', y') - (x_R, y_R) = w((x, y) - (x_T, y_T))$ or $(x', y') = (wx + x_R - wx_T, wy + y_R - wy_T)$. Let T' be the texture-allocated image and $T_l'(x, y)$ be the luminance of (x, y). Then, the allocation can be described by (2). Fig. 4(b) shows an example of such allocation with $w = 2$.

$$T_l'(x, y) = R_l(wx + x_R - wx_T, wy + y_R - wy_T) \quad (2)$$
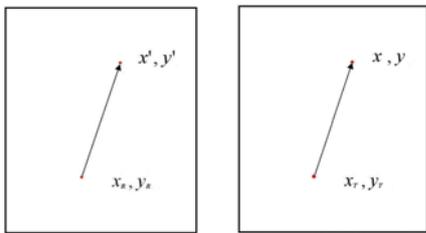
<center>(a) reference image R   (b) target region T</center>
<center>Fig. 3 Correspondence of the points selected from two images</center>

<center>(a) Reference texture image   (b) Texture allocate results</center>
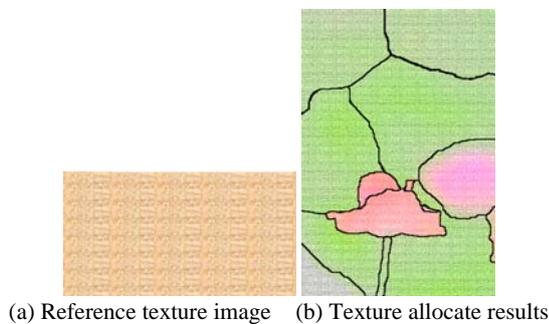
E. Allocation 3:

In order to retain the original mean luminance of the target image, the system provides another version of allocation which simply adds the difference of the luminance of its corresponding pixel from the mean luminance in the reference image, as shown in (3). Fig. 5 shows an example of such allocation.

$$T_l'(x, y) = T_l(x, y) + (R_l(wx + x_R - wx_T, wy + y_R - wy_T) - m) \quad (3)$$
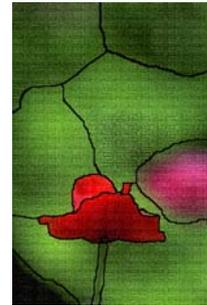

<center>Fig. 5 Texture allocation (Allocation 3, w = 2)</center>

III. EXPERIMENTAL RESULTS

Our experiments were implemented using the Windows XP operating system on a 2.0 GHz P4 PC with 1GB memory using a Borland C++ Builder 6.0 compiler. Test images were downloaded from the Internet [8].

Fig. 6 shows a stylization result using a single reference image. Stylization can be carried out by more than one of the allocation methods with more than one reference image. This makes the system more flexible and practical in use, especially for interior design. Figs. 7 and 8 show some stylization results with the combination of different allocations using more than one reference image.
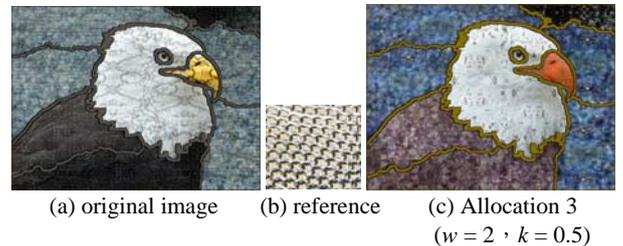
<center>(a) original image   (b) reference   (c) Allocation 3</center>
<center>$(w = 2, k = 0.5)$</center>
<center>Fig. 6 Allocation result using a single reference image (1)</center>

(a)   (b)

Fig. 7 Stylization results by a combination of different allocations


(a)   (b)

(c)
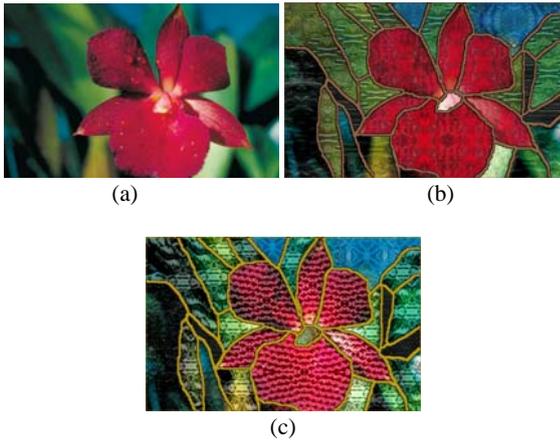
Fig. 8 Stylization results by a combination of different allocations with more than one reference images-2 (a) original image (b) & (c)

(a) original image   (b) result of S. Brooks

(c) allocation (1)   (d) allocation (2)

Fig. 9 Comparison with other methods

Although the method proposed by S. Brooks [7] can automatically stylize the target image according to reference images in a database to produce a stylized image, their method lacks flexibility. Unlike the method proposed by S. Brooks, our system provides a variety of ways to achieve stylization, so that the users can stylize each segment region of the target in different way by selecting an allocation version and giving values of parameters. Depending on their preferences, the users can emphasize texture or color and choose whether or not to retain the information of the target image. In Fig. 9, Fig. 9(b) shows the result of S. Brook's method. Figs. 9(c)-(d) show the results of our method, which preserves the waves on the lake.

IV. CONCLUSION AND FUTURE WORK

We proposed an image stylization system that provides a variety of options for users to choose from. Experimental results show that our system is easy and flexible to manipulate and provides satisfactory stylization results. Since manual segmentation takes too much time and is too costly, we will continue to study and look for solutions to these problems. We expect to find a more efficient and effective automatic or semi-automatic segmentation method that meets users' requirements. In the future, we would like to extend our study to different types of stylization.

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