Every Color Chromakey

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Abstract

In this paper, we propose a region extraction method using chromakey with a two-tone checker pattern background. The proposed method solves the problem in conventional chromakey techniques that foreground objects become transparent if they have the same color with the background. The adjacency condition between two-tone regions of the background and the geometrical information of the background grid lines are utilized for extracting foreground objects. Experimental results show the effectiveness of the proposed method.

1 Introduction

Image composition is very important to creative designs such as cinema films, magazine covers, promotion videos, and so on [1]. This technique can combine images of actors or actresses in a studio and those of scenery taken in other places.

To perform image composition, objects of interest must be segmented from images. There are a lot of studies about image segmentation, *e.g.* pixel-based, area-based, edge-based, and physics-based ones. For example, Snakes [2] was proposed as an effective technique based on edge detection. However, there have not been developed practical methods which are accurate and automatic, while a method with high accuracy is proposed which is realized by human assistance [3].

Chromakey, which is also referred to as color keying or color-separation overlay, is a well-known image segmentation technique that removes a color from an image to reveal another image behind. Objects segmented from a uniform single color (usually blue or green) background are superimposed to another image.

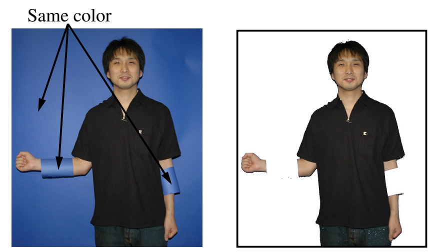
In image composition, the color $I(u,v)$ of a composite image at a pixel (u,v) is defined as:

$$I(u,v) = \alpha(u,v)F(u,v) + (1-\alpha(u,v))B(u,v), \quad (1)$$

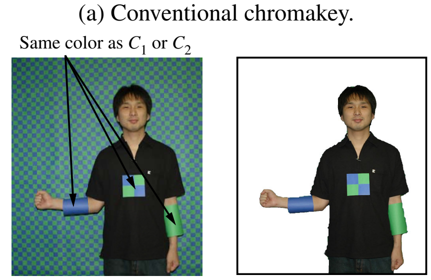
where $F(u,v)$ and $B(u,v)$ are the foreground and the background color, respectively, and $\alpha(u,v)$ is the so-called alpha key value at a pixel (u,v) [1]. The color at a pixel (u,v) is the same as that of the foreground when $\alpha(u,v)$ equals to 1, and is the same as that of the background when $\alpha(u,v)$ equals to 0. In chromakey, it is very important to determine the alpha value exactly. Methods for exact estimation of the alpha value have been proposed in applications of hair extraction, transparent glass segmentation, and so on [4–7].

However, conventional chromakey techniques using a monochromatic background have a problem that foreground objects are regarded as the background if their colors are similar to the background, and the foreground regions of the same color are missing (Figure 1(a)).

To solve this problem, Smith and Blinn proposed a blue screen matting method that allows foreground objects to be shot against two backing colors [8]. This method can extract the foreground region whose colors are the same as the background color. However, this alternating background technique cannot be used for live



(a) Conventional chromakey.



(b) Every color chromakey (C_1, C_2: background color).

Figure 1. Chromakey techniques.

actors or moving objects because of the requirement for motionlessness within a background alternation period.

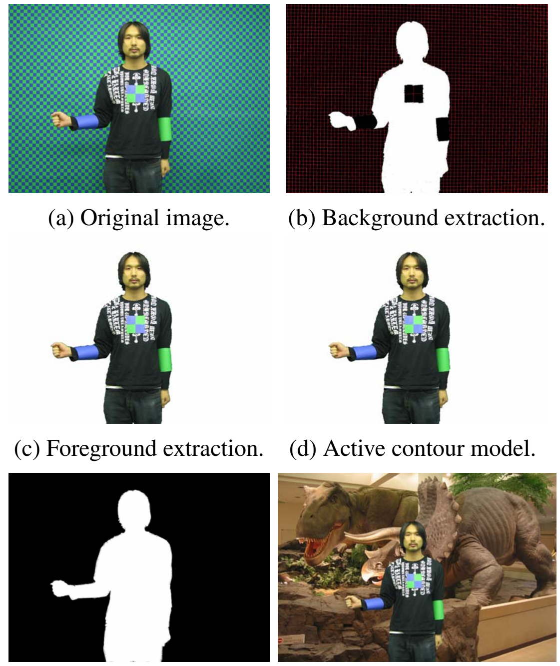
In order to solve the above problem, we proposed a method for segmenting foreground objects from a background even if objects have a color similar to the background [9, 10]. In these methods, a patterned background is used for extracting foreground objects whose colors are similar to the background. Basically, these methods only decide the alpha values as 0 or 1 discretely, and exact alpha value estimation is not considered. In other words, these methods mainly treat segmentation problems, not composition problems.

In this paper, we propose a new chromakey method that can treat foreground objects with arbitrary shape in any color by using a two-tone checker pattern background (Figure 1(b)). The proposed method estimates exact alpha value and realizes natural compositions of difficult regions such as hair.

2 Every Color Chromakey

The procedure consists of three steps; background extraction (Figure 2(a)(b)), foreground extraction (Figure 2(c)(d)), and image composition (Figure 2(e)(f)).

As to foreground extraction, the boundary between the foreground and the background is detected to recheck the foreground region whose color is same as the background. To detect the region whose color is same as the background, the method employs the condition that the endpoints of checker pattern touch the foreground contour. If the foreground object has the same color as the background and has parallel contours with the background stripes, endpoints of the checker pattern region do not touch the foreground contour.



(a) Original image. (b) Background extraction.
(c) Foreground extraction. (d) Active contour model.
(e) Alpha matte. (f) Image composition.

Figure 2. Procedure.

2.1 Background Extraction

Candidate regions for the background are extracted by using a color space approach.

Let R_1 and R_2 be the regions whose colors are C_1 and C_2, respectively, where C_1 and C_2 are the colors of the two-tone background in an image captured with a camera. In addition to regions R_1 and R_2, intermediate grid-line regions between R_1 and R_2 are also candidates for the background (red lines in Figure 2(b)).

The color of grid-line regions may be a composite of C_1 and C_2, which is different from C_1 and C_2. Here, let C_3 be the color belonging to grid-line regions or foreground region.

It is necessary to estimate C_1 and C_2 in individual images automatically to improve the robustness against the change of lighting conditions. We realize this automatic color estimation by investigating the color distributions of the leftmost and rightmost image areas where the foreground objects do not exist. The colors in these reference areas are divided into C_1, C_2 and C_3 in the HLS color space by using *k-mean* clustering. The HLS color space is utilized because color segmentation in the HLS color space is more robust than in the RGB color space against the change of lighting conditions.

Background grid line regions contact with both R_1 and R_2. Colors of the upper and lower areas of horizontal grid-line regions differ from each other. The same is true for left and right areas of vertical grid-line regions. Therefore, background grid lines are extracted by using adjacency conditions between two background colors.

However, if grid-line regions are included in foreground objects, *e.g.*when a person wears in part a piece of cloth having the same checker pattern as the background (Figure 2(a)), these regions can not be distinguished whether foreground or background. Therefore, we apply a rule that background grid lines should be elongated from those given in the reference area where foreground objects do not exist. If grid lines in foreground objects are dislocated from background grid lines as shown, they are regarded as foreground regions.

In this stage, all regions whose colors are same as the background are extracted as the background candidates, which may include mis-extracted regions as illustrated in Figure 2(b). Those are regions which belong to the foreground object but have the same color as the background. We define foreground regions whose colors are different from the background as normal-foreground region, mis-extracted regions isolated from the background as inside-same-color region, and neighboring to the background as surface-same-color region, respectively. These errors are corrected in the next step.

2.2 Foreground Extraction

Background candidate regions corresponding to inside-same-color regions and surface-same-color regions should be reclassified as the foreground, although their colors are same as the background. This reclassification can be realized by adopting the following rules concerning to adjacency with background grid lines.

If there is a background region candidate that does not connect with the background grid line regions, it is reclassified as the foreground region. Therefore, inside-same-color regions can be judged as foreground.

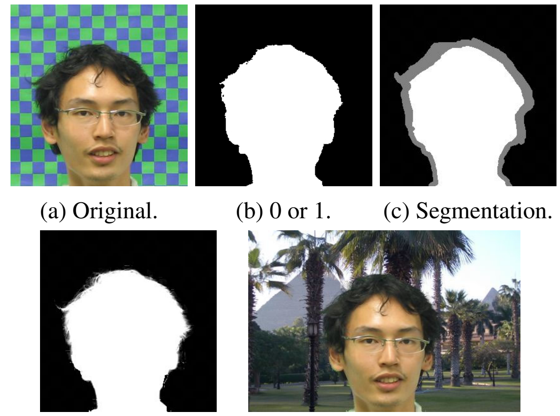
If there is a background region candidate which has an endpoint of a background grid line in its inside, it is divided into two regions; one is a foreground region and the other is a background. The dividing boundary of the two regions is given by a series of the interpolation lines each of which is a connection of neighboring background grid-line endpoints. The region containing the background grid line is regarded as the background, and the other (surface-same-color region) is regarded as the foreground region.

By completing the above procedures, the image is divided into foreground and background regions. However, the contours of the foreground objects may not be exact ones, because the interpolation lines do not give fine structure of the contours owing to the simplicity of straight line connection (Figure 2(c)). Therefore, we execute contour refinement which is realized by using an active contour model approach (Figure 2(d)) [2][1] .

2.3 Image Composition

The extracted foreground image and another background image are combined by using Equation (1).

The alpha values for the background pixels are decided as 0 (black regions in Figure 3(b)), and those for the foreground pixels are decided as 1 (white regions in Figure 3(b)) by using an active contour model approach. It is important to decide binary alpha values



(a) Original. (b) 0 or 1. (c) Segmentation.

(d) Alpha matte. (e) Composite image.

Figure 3. Image composition.

for region extraction, however, alpha values of boundary regions between foregrounds and backgrounds are neither 0 nor 1. Therefore, we estimate alpha values by using a Bayesian approach to digital matting [6].

Conservative foregrounds (white regions in Figure 3(c)), conservative backgrounds (black regions in Figure 3(c)), and unknown regions (grey regions in Figure 3(c)) are segmented from the region extraction result by using foreground extraction results by an active contour model. Alpha value, in other words, an opacity for each pixel of the foreground element, is estimated by using a modified Bayesian matting method that can extract same color regions with backgrounds (Figure 2(e) and 3(d)), and a natural composite image is generated by using the opacity[2] (Figure 2(f) and 3(e)).

3 Experiments

In experiments, we selected blue and green as the colors of the checker pattern background, because they are complementary colors of human skin color and generally used in chromakey with a unicolor background. The pitch of the checker pattern was 30mm$\times$30mm. The method has been verified in an indoor environment with humans whose clothes were diverse in color.

Figures 4(a)(b)(c) and 5 show composite results of still images and moving image sequence, respectively. These results show that the foreground regions whose colors are the same as the background color are extracted and composited exactly without fail.

[1] Note that the contour model should not be attracted to the edges belonging to the background grid lines. The horizontal and the vertical background grid lines are regarded as edges that have large intensity gradients along the vertical and the horizontal directions, respectively. Therefore, we make directionally selective calculation of intensity gradients for pixels belonging to grid-line regions [10].

[2] Note that an active contour model is essential to our method for deciding initial foreground regions and dividing image into three regions. Our method cannot work well without an active contour model, because initial foreground contours is important for estimating opacity for same color regions with backgrounds.

(a) Same colors as background.

(b) Same color checker pattern as background.

(c) Hole (Person who holds his pelvis with his left hand).

(d) Without alpha estimation. (e) With alpha estimation.

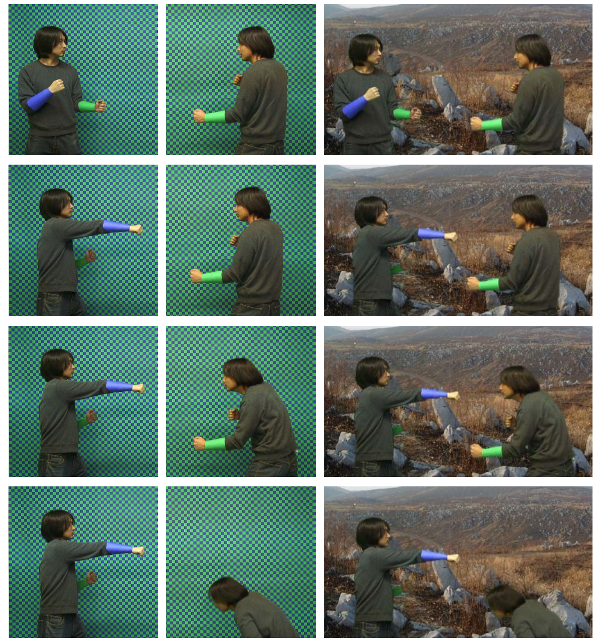
Figure 4. Experimental result 1.

Figure 4(d) shows a composite result without alpha estimation and Figure 4(e) (enlarged result of Figure 2(f)) shows a result with an alpha estimation. From these results, it is verified that natural compositions of difficult regions such as hair can be realized.

4 Conclusion

In this paper, we proposed a new chromakey method using chromakey with a two-tone checker pattern background. The method solves the problem in conventional chromakey techniques that foreground objects become transparent if their colors are the same as the background color.

Experimental results show that foreground objects can be segmented exactly from the background and natural compositions can be realized by estimating exact alpha value, regardless of the foreground object color.



(a) (b) (c)

Figure 5. Experimental result 2.

References

[1] T. Porter and T. Duff: "Compositing Digital Images," *Proc. SIGGRAPH*1984, Vol.18, No.3, pp.253–259, 1984.

[2] M. Kass, A. Witkin and D. Terzopoulos: "Snakes: Active Contour Models," *Int. J. of Computer Vision*, Vol.1, No.4, pp.321–331, 1988.

[3] Y. Li, J. Sun, C.-K. Tang and H.-Y. Shum: "Lazy Snapping," *Proc. SIGGRAPH*2004, pp.303–308, 2004.

[4] M. A. Ruzon and C. Tomasi: "Alpha Estimation in Natural Images," *Proc. IEEE CVPR*2000, pp.18–25, 2000.

[5] P. Hillman, J. Hannah and D. Renshaw: "Alpha Channel Estimation in High Resolution Images and Image Sequences," *Proc. IEEE CVPR*2001, Vol.1, pp.1063–1068, 2001.

[6] Y.-Y. Chuang, B. Curless, D. H. Salesin and R. Szeliski: "A Bayesian Approach to Digital Matting," *Proc. IEEE CVPR*2001, Vol.2, pp.264–271, 2001.

[7] J. Sun, J. Jia, C.-K. Tang and H.-Y. Shum: "Poisson Matting," *Proc. SIGGRAPH*2004, pp.315–321, 2004.

[8] A. R. Smith and J. F. Blinn: "Blue Screen Matting," *Proc. SIGGRAPH*2004, pp.259–268, 1996.

[9] A. Yamashita, T. Kaneko, S. Matsushita and K. T. Miura: "Region Extraction with Chromakey Using Stripe Backgrounds," *IEICE Trans. on Info. and Sys.*, Vol.87-D, No.1, pp.66–73, 2004.

[10] H. Agata, A. Yamashita and T. Kaneko: "Chroma Key Using a Checker Pattern Background," *IEICE Trans. on Info. and Sys.*, Vol.90-D, No.1, pp.242–249, 2007.