Elimination of the Red-Eye Area using Skin Color Information

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Abstract—The red-eye effect in photography occurs when using a photographic flash very close to the camera lens, in ambient low light due to in experience. Once occurred, the photographer needs to remove it with image tool that requires time consuming, skillful process. In this paper, we propose a new method to extract and remove such red-eye area automatically. Our method starts with transforming RGB space to YCbCr and HSI space and it extracts the face area by using skin color information. The target red-eye area is then extracted by applying 8-direction contour tracking algorithm and removed. The experiment shows our method's effectiveness.

Index Terms—Red-eye, YCbCr, HSI, Face Area, Skin Color, 8-direction Contour Tracking Algorithm.

I. INTRODUCTION

While the usage of digital camera is continuously increasing, there are many low quality photos by novices due to immatured photographing techniques or low cost, low quality cameras. Especially it is uncomfortable to have red-eye effects in portrait photos affected by flashing effect, angles, or backlight. The red-eye effect appears when blood vessels located at the retina in the pupil are printed in the photo due to the reflection of the flash. It occurs when using a photographic flash very close to the camera lens, in ambient low light due to inexperience and more frequently happens to the photos of foreigners with non-black eyes than ones with black eyes [1]. Such unwanted side effect may cause photos not be in collection.

In this paper, we propose a method to remove such red-eye effect by image processing technique. In our method, the photo image is transformed to YCbCr and HSI color space and the skin color region is extracted by using skin color prior information. Then, the 8-directional contour tracking algorithm is applied to extract red-eyed face and eye region and remove that part with correct eye color model.

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II. EXTRACTION AND REMOVAL OF RED-EYE REGION WITH SKIN COLOR INFORMATION

In this section, we explain the procedure to transform original RGB space to YCbCr, HSI space and to extract target region by applying the 8-directional contour tracking algorithm and smearing method.

A. Space Transform of Skin Color Information

In this paper, we use YCbCr and HSI space in order to extract human face region in the photo using skin color information [2]. The role of YCbCr space is to extract skin color information by applying formula (1) and threshold values as Table 1. Likewise, transforming it to HSI color model by applying formula (2) and threshold values shown in Table 2 is used for extracting the same sort of information.

$$\begin{aligned} Y &= (0.2999\times R)+(0.587\times G)+(0.114\times B) \\ Cb &= (-0.1687\times R)-(0.3313\times G)+(0.5\times B)+128 \\ Cr &= (0.5\times R)-(0.4187\times B)-(0.0813\times B)+128 \end{aligned} \quad (1)$$

Table 1. Thresholds of Skin Color Information in YCbCr Color Model

	Y	Cb	Cr
Threshold	74-255	0-255	135-255

$$H = \cos^{-1}\left[\frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right]$$
$$S = 1-\left(\frac{3}{R+G+B}\right)[\min(R,G,B)] \qquad (2)$$
$$I = \frac{1}{3}(R+G+B)$$

(a) original image

(b) Transformed to YCbCr Color Model

(c) Transformed to HSI Color Model

(d) After (b) AND (c)

Fig.1 Processes for extracting candidate face region

Table 2. Thresholds of Skin Color Information in HSI Color Model

	H	S	I
Threshold	0-255	10-130	72-220

After those processes, we apply binarization procedure to both of them as the value becomes 0 if the value of the pixel is 255 and 255 otherwise. Then the AND operation is applied to extract the candidate face region as one can see in Fig. 1 (d).

B. Extracting Face and Eye Region

We use 8-directional contour tracking algorithm to extract face region from image of candidate face region like Fig. 1 (d). This algorithm uses mask shown as Fig. 2 in contour tracking. When the boundary pixel meets P in the mask, the masking is performed from 0 position to 7 position in clockwise order. Then, the coordinate of next boundary pixel is moved to P position and the next tracking is started with the location rotated by -90 degrees. The tracking is finished when the mask returns to the start position or there exists no object pixel in all of 8 directions [3,4].

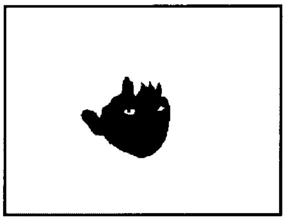
5	6	7
4	P	0
3	2	1

Fig. 2 3X3 Mask

After going through this process, we apply region expansion method, vertical and horizontal smearing method[5] and noise reduction to obtain the final face region extraction in order.

From there, we regard the region that |Max(R,G,B) - Min(R,G,B)| is equal to or less than 50 pixels as candidate eye region. Then the same procedures - region expansion method, vertical and horizontal smearing method and noise reduction are applied to finalize the eye region. Fig. 3 shows the result of above processes.

(a) Face region from original image by 8 directional contour tracking method



(b) Result from binarized image by applying 8 directional contour tracking method and vertical/horizontal smearing method

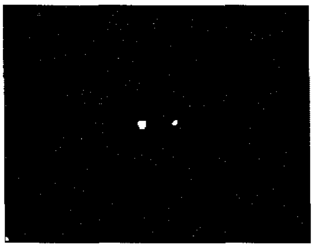
(c) Extracting eye region with red-eye effect

Fig. 3 Processes of extracting eye region

The red color is on the pupil. The pupil is defined as a part of eye region whose R value is more than two times of G value. A partial compensation procedure such as formula (3) is applied to R value to the pupil region.

$$R = \alpha \times (0.05 \times R + 0.6 \times G + 0.3 \times B) + (1 - \alpha) \times R \qquad (3)$$

The result of above procedure is shown as Fig. 4 and Fig. 5.



(a) Extracted Pupil Region

(b) Red-eyed region from (a)

Fig. 4 Extracting red-eyed region

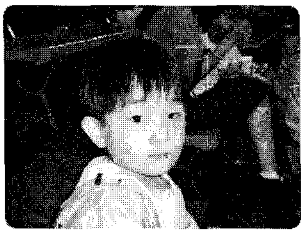


Fig.5 Removing red-eyed effect from original image

III. EXPERIMENT AND RESULT ANALYSIS

The experiment is done with IBM compatible Pentium-IV PC with 3GHz CPU and 512MB memory, implemented by Visual C++. We use 30 images in experiment with various characteristics. The result is summarized in Table 3.

Table 3. Performance evaluation of extraction of red-eyed region by proposed method

	Face	Eye	Removal
Red-Eyed (Asian)	20 / 23	18 / 23	18 / 23
No Red-Eye (Asian)	2 / 2	2 / 2	0 / 2
No Red-Eye (Black)	2 / 2	1 / 2	0 / 2
No Red Eye (White)	2 / 3	2 / 3	0 / 3

Extracted / Input

In summary, the face recognition rate is 87%, Eye region extraction rate is 77% and successful red-eyed region removal is complete when the eye region is correctly extracted. However, there are a few cases that our method failed to obtain the face region when the skin color and the background color are undifferentiated as Fig. 6 and failed to extract the eye region when the morphological characteristic (the ratio between eye and eyebrow) is too much similar as shown in Fig. 7.

Fig. 6 Failed case of face extraction

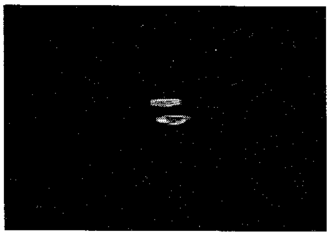


Fig. 7 Failed case of eye region extraction

IV. CONCLUSIONS

In this paper, we propose a method to extract and remove the red-eyed region from a photograph. In this method, we transform RGB color model to YCbCr and HSI model and then a series of image processing techniques – 8 directional contour tracking, vertical/horizontal smearing method etc. - are applied to the original image.

Through experiment, the proposed method is effective. The extraction rate of eye region is 77% and red-eye removal is 100% without any false positive if the eye region is extracted. However, there are several cases that the proposed method is not able to extract face region or eye region due to morphological indifferences.

Thus, our research will forego to apply fuzzy neural network technology to deal with such morphological factors in this problem.

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