Enhanced Method for Face Detection Based on Feature Color

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***Abstract*—This paper describes the human face detection based on special feature color. Here, the skin color was picked up as a special feature. The human's face was observed by the USB camera in real time. First of all, human face images were obtained under the various brightness environments. As a results, it was found that red component of the facial skin is stronger than any other facial parts such as eye, nostril or mouth. In our proposed system, the original image was changed into the rough color image and the smoothing procedure was applied to calculate the weight value of the skin color and eliminate noise. In cases where the head was tilted or the face was turned to the side, it is difficult for the existed method to detect the face, because it was adjusted for the frontal face. On the other hand, our proposed system could detect the tilted face and side face.**

***Index Terms*—face detection, image processing, RGB color, binalization, smoothing**

I. Introduction

In recent years, automatic face detection has been used on home optoelectronics devices, such as digital camera, and smartphone, as a matter of course. Many detection methods [1]-[8] have been proposed, however, the Viola-Jones method [6]-[8] has been mainly used for face detection of optoelectronics devices due to the fact that it can correctly find a human face for short time. On the other hand, this recognition algorithm had been constructed on the assumption that recognition target was limited to only frontal face. Therefore, side face cannot be detected and the tilted face is also ignored. To solve these problems, this study proposed a new method of face detection, based on special feature color. Here, the skin color was picked up as a special feature. As a same approach, improvements in Viola-Jones algorithm using both skin color and eyes position has been proposed for the tilted face detection [9]. We used only skin color information through smoothing process to convert the obtained original image into the rough color pixelization.

II. Facial Feature Points

A. Measurement

The flow and constitution of these systems disposal is showed in Fig. 1. USB camera (Logicool HD Webcam C615) was connected to a personal computer, converting the photographed image into bitmap image (24bit RGB color) in real time through the DirectShow filters on Microsoft Visual C# 2010. The obtained image was used to detect human face, based on image processing. Fig. 2 shows some sample pictures under the condition that the surrounding brightness was changed, well-lighted, gloomy and backlight situations. As shown in this figure, there are many objects on the background including shadows as a noise. For face detection, the OpenCV library [10] is well-known as useful software and it is famous for image processing, however, face recognition from the obtained image may be difficult in some cases due to influence of the neighboring brightness and faces hiding. In this study, original algorithm is suggested to realize simple and high-speed processing by this system. Here, we focused on feature point color of the human face.

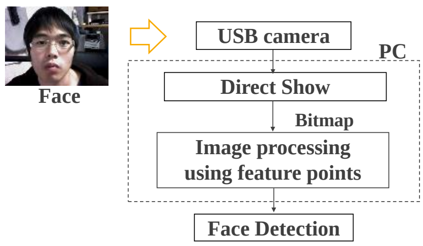

Figure 1. Device system configuration.

Figure 2. Images under the various situations.

B. Feature Points Color

First of all, RGB values of the facial image were analyzed. Eight image parts such as facial skin, nostril, lip, hair, pupil, white of the eye, eyebrow, and background, were selected to investigate special feature of RGB color. In this subsection, the color information of feature points was considered to detect the face of the

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obtained image. Fig. 3 shows RGB color information in cases where brightness of the face was changed as shown in Fig. 2, well-lighted, gloomy, and backlight situations. In this figure, the percentage of the RGB level about each feature point was plotted on a triangle graph. Although there is a little differences according to the surround brightness, the distribution relations of the color of RGB almost become the same shape. In addition, it is confirmed that ingredient of R on the skin, nostril, and lips are stronger than other domains. As for these three parts, the relation of $R > G > B$ was satisfied regardless of brightness. Above all, the differences between R and B could be seen remarkably. Furthermore, it is said that each ratio of RGB color about the skin, nostril, and lips is almost certain value. Fig. 4 shows the RGB value of the skin, picked up from Fig. 3(a), Fig. 3(b), and Fig. 3(c). From the obtained value, a condition to distinguish a pixel of skin was defined as follows:

$$\tilde{R} > \tilde{G} > \tilde{B},\ 2R > 3\tilde{B} \tag{1}$$

where, $(\tilde{R}, \tilde{G}, \tilde{B})$ was a RGB pixel color. The above is a magnitude correlation among RGB colors. In addition, a ratio among RGB colors was also used for detection circumstance.

$$\begin{cases} \varepsilon_{Low\_R} < \dfrac{\tilde{R}}{\tilde{R}+\tilde{G}+\tilde{B}} < \varepsilon_{High\_R} \\ \varepsilon_{Low\_G} < \dfrac{\tilde{G}}{\tilde{R}+\tilde{G}+\tilde{B}} < \varepsilon_{High\_G} \\ \varepsilon_{Low\_B} < \dfrac{\tilde{B}}{\tilde{R}+\tilde{G}+\tilde{B}} < \varepsilon_{High\_B} \end{cases} \tag{2}$$

here, $(\varepsilon_{Low\_R}, \varepsilon_{High\_R})$, $(\varepsilon_{Low\_G}, \varepsilon_{High\_G})$, and $(\varepsilon_{Low\_B}, \varepsilon_{High\_B})$ were threshold vales.

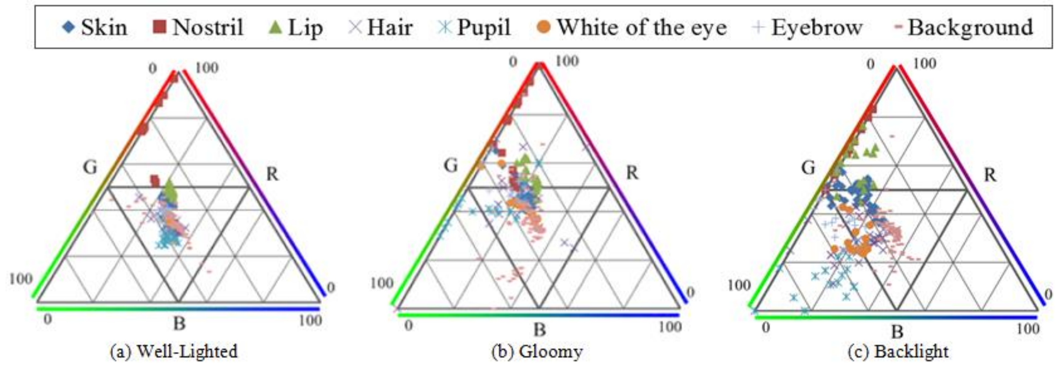

Figure 3. Color information of eight feature parts.

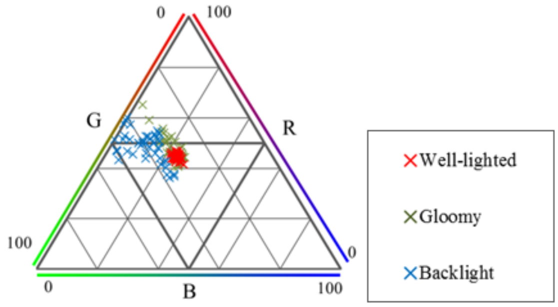

Figure 4. Color information of skin.

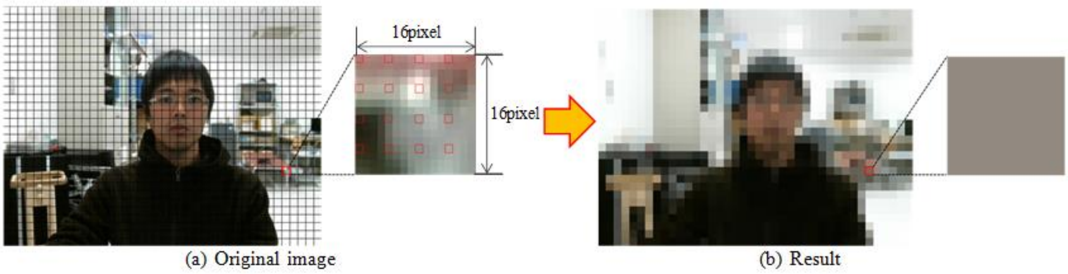

Figure 5. Pixelization.

C. *Procedure*

When the face is detected from the obtained image, the whole face must be regarded as one connection ingredient. In addition, shadow or glasses on the face may often interrupt a judgment of a connection ingredient. Therefore, the original obtained image was changed into a mosaic form in this algorithm. As shown in Fig. 5(a), the original image of 640×480 pixels was changed into 40×30 blocks as one block in 16×16 pixels.

Representative color (R′, G′, B′) of each block was derived from the average of the color of the representative point as follows.

$$(R',G',B') = \left(\sum_{i=0}^{3}\sum_{j=0}^{3} \frac{\tilde{R}[4i,4j]}{16}, \sum_{i=0}^{3}\sum_{j=0}^{3} \frac{\tilde{G}[4i,4j]}{16}, \sum_{i=0}^{3}\sum_{j=0}^{3} \frac{\tilde{B}[4i,4j]}{16} \right) \quad (3)$$

where, ($\tilde{R}[i,j]$, $\tilde{G}[i,j]$, $\tilde{B}[i,j]$) is a brightness of a pixel on the coordinate $[i, j]$. The mosaic image was obtained as shown in Fig. 5(b). Rough color information was used for face detection to eliminate the calculating time. Fig. 6 shows the domain satisfied with both (1) and (2). In this situation, it was easy to be affected by the noise due to surround brightness. Here, smoothing procedure was applied to the image file. Here, we adopted a method adding to 8 blocks, as shown in Fig. 7. Let sgn be $g[i, j]$ in the coordinates (i, j), evaluation value after smoothing is as follows:

$$g'[i, j] = \sum_{k=i-1}^{i+1} \sum_{k=j-1}^{j+1} g[i, j] \quad (4)$$

The result calculated by (4) is shown in Fig. 8. An evaluation becomes higher as the domain with the reddish tinge. The domain extracted above a certain level is shown in Fig. 9. In this figure, the domain of $g'[i, j] = 0$ were eliminated from the original image. Moreover, the largest domain was selected as shown in Fig. 10 and face was finally able to be detected.

Figure 6. Binarization result.

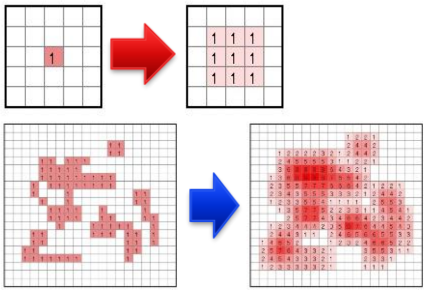

Figure 7. Smoothing.

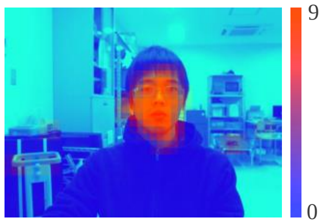

Figure 8. Smoothing.

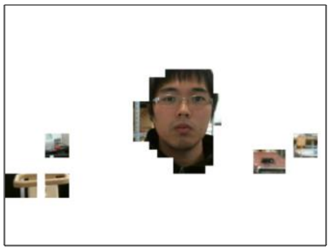

Figure 9. Region extraction.

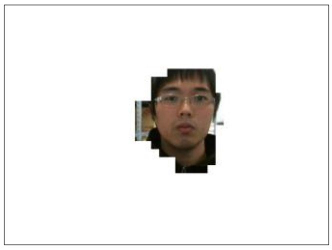

Figure 10. Choose largest one.

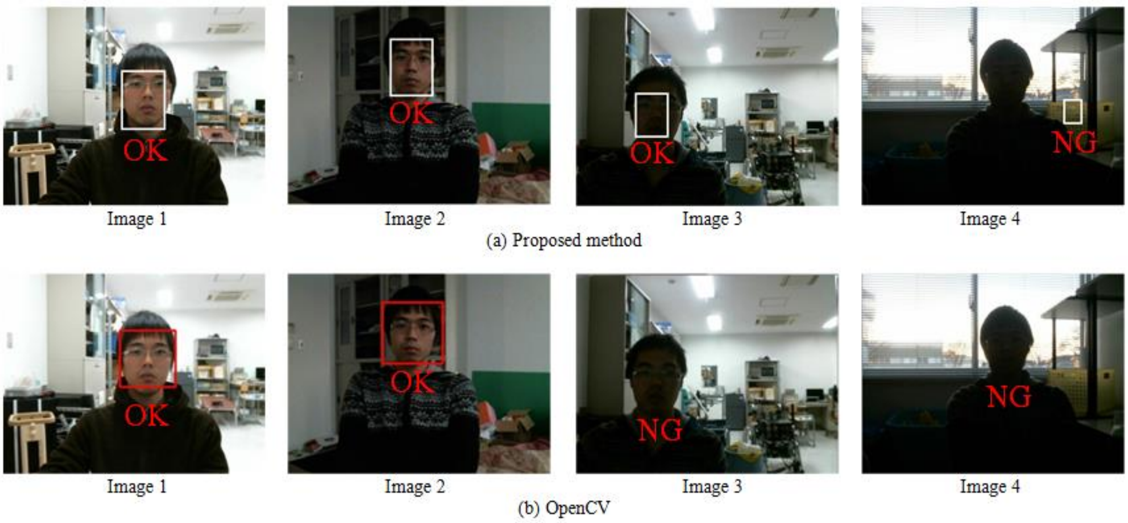

Figure 11. Recognition examples.

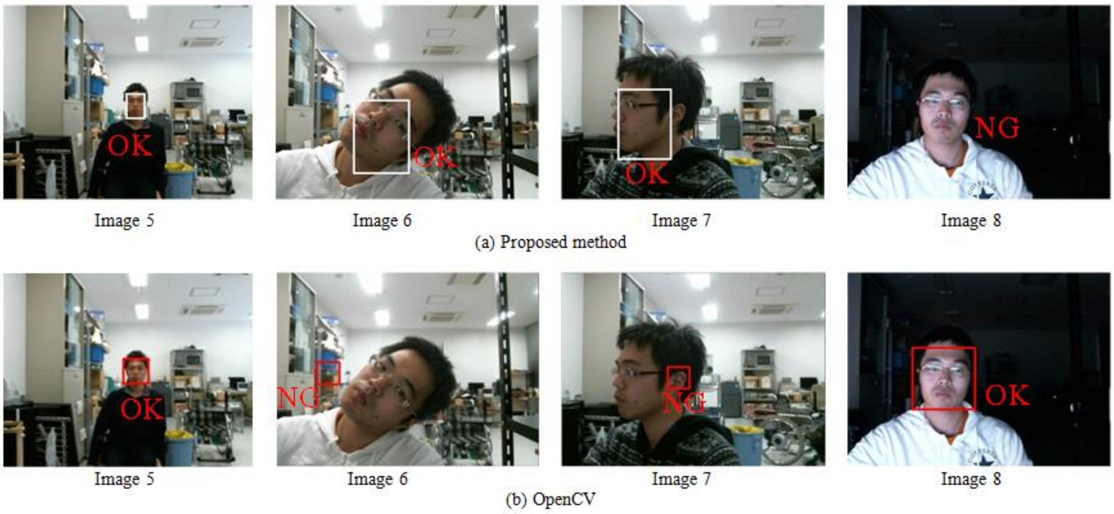

Figure 12. Recognition examples.

D. *Recognition Test*

In order to evaluate the proposed method, recognition test was carried out. Sample images of 640×480 pixels, which changed the conditions such as the angles of faces or neighboring brightness, were prepared for recognition test. In addition, it was decided that even a face detection function of OpenCV [10] took a similar step as this comparison with the algorithm. The results were shown in Fig. 11 and Fig. 12. Where, $\varepsilon_{\text{Low\_R}} = 0.38$, $\varepsilon_{\text{High\_R}} = 0.6$, $\varepsilon_{\text{Low\_G}} = 0.27$, $\varepsilon_{\text{High\_G}} = 0.49$, $\varepsilon_{\text{Low\_B}} = 0.02$, $\varepsilon_{\text{High\_B}} = 0.3$. These parameters were derived from the results of Fig. 4. The face of Image 1 and 2 were detected by the proposed algorithm as well as the method with OpenCV. Image 3 includes the gloomy situation, however, the proposed algorithm could detect the face parts, while the OpenCV could not find the face. In cases where the dark situation was treated, both methods could not recognize the face. As for Image 5, the face image was small, but both methods could detect it. When the face was tilted as shown in Image 6, the proposed method could find the face, and it is one of our strong points. In the case of Image 7, the method with OpenCV library mistook the ear for the face. With reference of Image 8, the proposed algorithm could not find the face, while the OpenCV successfully found it.

III. Summary

This paper proposed a new method of face recognition based on the feature color information. Here, we focused on the skin color as a feature point to detect the face from the image shot obtained by USB camera. In our system, the original image was firstly changed into the rough color image and the smoothing procedure was applied to it for calculating the weight value of the skin color and for eliminating noise. While the tilted head or side face could not be detected by only OpenCV, however, the proposed algorithm could detect them. As a future work, we would like to combine the proposed algorithm with the OpenCV library to enhance the face recognition system.

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