Recognition of the Spectacles Area from the Profile Image Based on Primary Differentiation Processing

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ABSTRACT

We propose a method to determine whether or not spectacles are worn from the profile image. Detecting straight lines and labeling from the profile image that emphasizes the line area and differentiated. It is possible to determine by calculating where the positions of the straight lines and the labeled objects.

1 Introduction

In Japan, about 70 % of the population wears spectacles, although the frequency of use varies, and it is necessary to consider a method that takes into account whether or not spectacles are worn in face image research. Currently, research on determining and detecting the presence or absence of eyeglasses has proposed a method[1] that models the spectacles frame and extracts the part of the face image that matches the model. However, this method is based on the structure of the spectacles frame, such as the bridge and clings, which exist only for the frontal face, so it is a challenge to deal with the horizontal rotation of the face, or profile images. Other method[2] has been proposed to extract spectacles frames by emphasizing line area using color information, but this method targets only frontal faces and do not consider profile faces. In addition, it is an issue to deal with spectacles without rims or missed frames.

In this paper, we focus on profile images as shown in Fig.1, and extract candidate area for spectacles by enhancing line area using color information and differentiating based on the feature that temples and rims of spectacles frames, which can be seen even from the profile, are often different in color from skin area. The extracted spectacles candidate areas are subjected to the straight lines detection and labeling process using the Hough transform, and the positions of the straight lines and labeled objects are obtained and calculated using the weighted image area by estimation of the profile direction to determine whether or not spectacles are worn.

Fig.1. An example of profile image

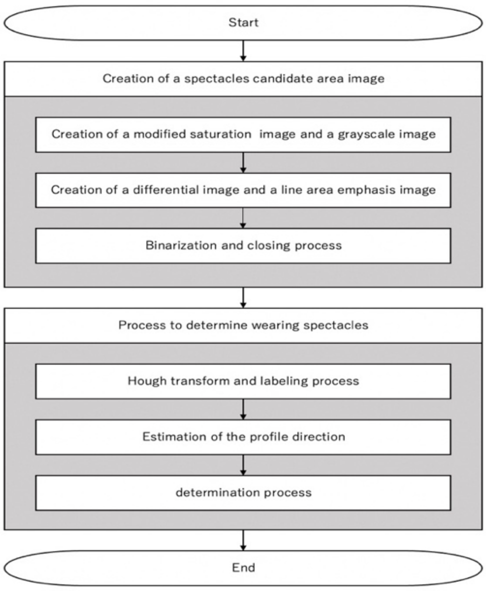


Fig.2. Flowchart of the proposed method

2 Determining whether or not spectacles are worn from the profile image

Fig.2, shows the flow of this method. The first step is to create a candidate spectacles area image. The next step is to determine whether or not spectacles are worn.

(a) Create a modified saturated image by extracting the modified saturated component in the modified HSV color system[3] from the input image and a grayscale image using the average value of RGB.

(b) From the two images created in (a), differential images are created by edge detection based on first order differential processing with the application of a vertical Prewitt filter that emphasizes horizontal edges.

(c) Create line area enhanced images based on the line area enhancement process[2] from the two images created in (a).

(d) The images created in (b) and (c) are binarized and processed for expansion and contraction. The size of the mask was set to 5 (x direction) x 3 (y direction). By calculating the logical product of the two binarized images after the closing process, the spectacles candidate area image (Fig.3) is created.

(e) Detect straight lines (line segments) from the image created in (d) using the Hough transform. Next, find the center point of each line segments.

(f) Perform the labeling process on the binary area that exist in the image created in (d). Next, find the center point of each labeled objects.

(g) Estimate whether the profile face left or right from the input image.

(h) The center points and profile direction obtained in (e), (f), and (g) are used to determine whether or not spectacles are worn.

2.1 Estimation of the profile direction

Basically, the direction of the profile is estimated using (2.1.1) below, but when the approximation rate is 90% or higher, the direction is estimated using (2.1.2) and (2.1.3) below. If the estimation results of (2.1.2) and (2.1.3) below are different, the estimation result based on the average of the pixel values in (2.1.1) below is used as the direction of the profile.

2.1.1 Average of pixel values

The input image is divided into left and right areas, the average of pixel values is calculated in each area, and the one with the higher pixel value is used as the profile direction. The approximation ratio of the average of pixel values of the left and right is obtained from equation (1).

$$A(\%) = \overline{f_s}/\overline{f_l} \times 100 \quad \text{.........equation (1)}$$

$\overline{f_s}$: The value with the lower average of the left and right pixel values

$\overline{f_l}$: The value with the higher average of the left and right pixel values

Fig.3. Spectacles candidate area image

2.1.2 Detecting eye areas using a cascade classifier

In this paper, we perform detection using the eye cascade classifier provided in OpenCV, and enclose the detected eye area with a rectangle. In order to reduce the number of false positives, the same process is applied to the horizontally flipped input image, and the overlap ratio of the two rectangles is obtained from equation (2).

$$D(\%) = a_d/(a_n + a_i - a_d) \times 100 \quad \text{......equation (2)}$$

a_d: Area of the overlapping rectangles

a_n: Area of the detected rectangle for the normal input image

a_i: Area of the detected rectangle for the horizontally flipped input image.

When the overlap ratio is 50% or more, the overlapping area is enclosed in a rectangle and the correct eye area is assumed to have been detected. The center point of the overlapping rectangle is determined and the direction is estimated based on whether it exists on the left or right side in the image.

2.1.3 Feature points extraction using the ORB algorithm

Extract feature points from the input image using the ORB algorithm. Among the extracted feature points, the direction is estimated based on whether the x coordinate of the feature point with the largest y coordinate exists on the left or right side.

2.2 Determination process

The image of the spectacles candidate area is divided into 3×3 grid like areas. Determine whether spectacles are worn by calculating where the line segments detected in (e) and (f) above and the center point of the labeled object are located in the divided area.

2.2.1 Determination by line segments

Depending on the direction of the profile estimated in (g) above, the divided area is weighted as shown in Fig. 4(a). The center points of the detected line segments is calculated for the weighted area, and the determination value V_l is obtained using equation (3).

$$V_l = c_l / N_l \text{.........equation (3)}$$

c_l: Sum of the weight of the area multiplied by the number of line segments present in the area

N_l: Total number of detected line segments

If this value is higher than the threshold, it is determined that the person is wearing spectacles. If no line segments are detected or the threshold value is not met, determination by labeled objects is performed.

2.2.2 Determination by labeled objects

From the result of (g), weight the divided area as shown in Fig.4(b), and calculate the center points of the labeled objects for the weighted area. The determination value V_{r1} is obtained by equation (4).

$$V_{r1} = c_{r1} / N_r \text{.........equation (4)}$$

c_{r1}: Sum of the weight of the area multiplied by the number of objects present in the area

N_r: Total number of objects

Next, the weighting of the area (Fig.4(c)) is performed to take into account the effect of false positives, and calculated in the same way. Equation (5) is used to obtain the discriminant value V_{r2}.

$$V_{r2} = c_{r1} / c_{r2} \text{...........equation (5)}$$

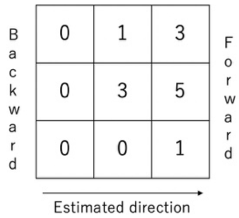
c_{r2}: Sum of the weight of the area multiplied by the number of objects present in the area

If the determination values V_{r1} and V_{r2} are both equal to or greater than the respective threshold values, it is determined that the person is wearing spectacles. If the threshold values are not met, it is determined that the person is not wearing spectacles and the process is terminated.

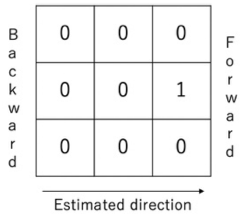
3 Experimental results and discussion

3.1 Experimental conditions

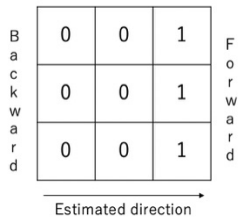
The experiment was conducted using 224 profile



(a) Weight for determination using line segments



(b) Weight for determination using labeled objects



(c) Weight considering false detection for determination using labeled objects

Fig.4. Area weighting

images(112 images wearing spectacles and 112 images without spectacles.) with a uniform background and various left and right directions of the face as input images. The image size is 320 x 256 pixels. The various parameters were set as follows. The threshold of binarization was set to 0.06 for the differential image, 0.05 for the line area enhanced image, 1.8 for the determination by line segments, and 0.32 and 0.52 for the determination by labeled objects.

3.2 Experimental results and discussion

3.2.1 Experimental results of estimation of the profile direction

Table.1(a) shows the experimental results of estimation of the profile direction. The experimental results show that estimation of the profile direction was reliable with or without wearing spectacles.

Tabale.1. Experimental result

	Profile wearing spectacles images	Profile not wearing spectacles images
(a)Correct estimation rate	99.1%	96.4%
(b)Correct determination rate	96.4%	92.6%
(c)Correct determination rate using only determination using line segments	75.7%	96.3%
(d)Final correct determination rate	95.5%	89.3%

3.2.2 Results of an experiment to determine whether or not spectacles are worn.

Next, we determined the wearing of spectacles for the 209 input images for which the correct experimental results were obtained by (3.2.1), and obtained the results shown in Table.1(b). Although the determination results of the profile images without spectacles were not as good as those of the profile images with spectacles, both were accurate enough to show the effectiveness of our method. As a comparison, Table.1(c) shows the results of an experiment in which only line segments determination was used to determination the wearing of spectacles, without determination by labeled objects. By using the determination by labeled objects, the correct determination rate of profile images without spectacles is slightly decreased, but the correct determination rate of profile images with spectacles is greatly improved. Finally, Table.1(d) shows the results of performing both estimation of the profile direction and determination of wearing spectacles from 224 input images.

4 Conclusions

In this paper, we show how to discriminate whether or not spectacles are worn from profile images, which has not been investigated using conventional methods. By calculating the weighted image area by estimation of the profile direction and the candidate spectacles areas that exists there, we achieved reliable determination of whether or not spectacles are worn. In addition, by using the line segments detected by the Hough transform and the labeling process, we were able to cope with the case where the spectacles frame is missing. Future work includes the weighting of areas corresponding to vertical rotation and the study of methods that are robust to hair type and hair color.

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