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Iris Tracking for Generating Novel Facial Interface Media

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Abstract

We took the face, especially eye or eye gaze, into consideration for discussing the non-verbal interface media. We first proposed a passive eye-camera system based on the facial image processing such as Hough transform for iris recognition. Next we proposed a method for generating eye-contacted facial images by computer image processing for enforcing and improving the quality of facial, nonverbal communication on the net such as VIDEO conference. Finally we applied these two proposed methods to the real environment of E-mail daily conference in the production process of the company, and shortly discussed on the prospects of the facial new media on the net.

1 Introduction

Human Communication on the network environment is becoming primal even in the industrial production processes and the non-verbal media for the communication such as face is likely to be neglected or be in fatally low quality.

As commonly known, so-called "emoticon" characters have been utilized for compensating the lack of the "non-verbal" information (facial expression, gesture) in computer-mediated communications. However, it is becoming expectable to introduce directly several kinds of facial image media into the communication network infrastructure [1].

First we propose a system for extracting eye gaze information. In the E-mail case, for example, the sender wants to know how well the receiver can understand the conversation content or not. To do this it is usually expected to utilize facial images. But, the face image is too large to be exchanged to each other. So, we paid attention to the digested features of eye gaze pattern on the E-mail letter extracted from the facial images by iris recognition.

Next, we introduce a system for supporting VIDEO conference system. Recently, VIDEO conference system could be used easily even in the mobile phone environment with camera, and many people use it in daily life. Since human is likely to look at the face of his partner on the monitor not at camera, he will usually fail to send his own eye-contacted facial images to him, and vice versa. The basic idea to improve this fatal communication degradation is to regenerate facial image by changing the direction of the irises in the same original facial image.

2 Facial Parts Tracking

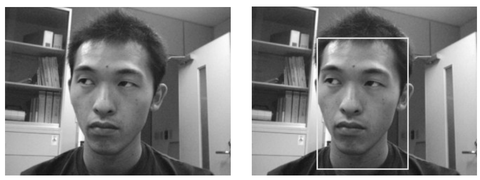
2.1 Face region extraction

The images with 24bit color and QVGA (320x240) in size were taken in an indoor circumstance. First, we extract a skin region by using color image. Here we used HSV color table [2].

To put it concrete, let the color transform system be eq. (1) and a set of hue image, saturation image and value image be generated.

$$H = tan^{-1}(C_1 / C_2) \qquad S = \sqrt{C_1^2 + C_2^2} \qquad V = -0.3R - 0.59G + 0.89B \qquad \left(\begin{array}{l} C_1 = R - Y = 0.7R - 0.59G - 0.11B \\ C_2 = B - Y = -0.3R - 0.59G + 0.89B \end{array} \right) \tag{1}$$

Next, erosion, dilatation and labeling are applied to detect the skin region. Fig.1 (b) shows an example of the face region extracted from the image given in Fig.1 (a).



(a) Original Image (b) Skin Region
Figure 1. Face region extraction

2.2 Limitation of eye region for iris recognition

Eye region is limited by using the extracted facial region. First, contrast improvement, horizontal edge emphasis and binarization are applied to the extracted facial region. Next, the number of pixels is counted from the center of face region for thresholding the region, and the eye region is located as shown Fig. 2.

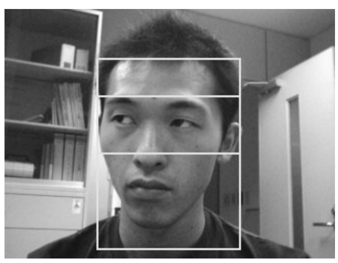
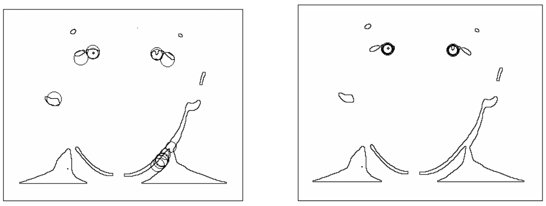


Figure 2. Limitation of eye region by facial region

2.3 Iris Recognition

A method for recognition of irises from the gray images is proposed by using Hough transform for circle detection. Several candidates of a pair of the irises were extracted at first by applying Hough transform for circle detection to the binary image. The binarization method was especially constructed by the method given in [3]. The voting ranges of the parameter space (a, b, r) were limited to some extent in order to reduce the computation cost and to enforce the performance. Parameters a and b indicate the centre of iris. Parameter r indicates the radius of the iris. The best pair of the irises is detected from the candidates in accordance with the criteria standards given by that the number of votes is bigger, that the positional relation between left and right irises is horizontal and that the radius of the left equals to the right.

Fig.3 shows an example of the iris selection processing. Fig.3 (a) is an example of the experimental result. The one with the shortest segment that connects a right and left iris is adopted for the iris candidate. As shown in Fig.3 (b), it is understood that the circle drawn in the extraction result shows the iris position, and the iris is extracted accurately in the image.



(a) Candidates of irises (b) Selected pair of irises

Figure 3. Iris recognition

2.4 Evaluation of iris

Irises were recognized by section 2.3. However, eyebrow must be extracted as irises in this processing. Therefore, It is necessary to limit more precisely the eye region and to check whether a pair of circles is irises or not.

Limit of eye regions is provided by each iris positions in previous frames. Each new region is determined by eq.(2) based on the radius of iris. Center of iris positions of the previous 5 frames are saved, the average value is calculated. Fig.4 shows an example of the limited eye regions.

Eye Region_L = (circle_l_length.x) *(circle_l_length.y)
Eye Region_R = (circle_r_length.x) *(circle_r_length.y) (2)
(each lengths are computed by radius of iris)

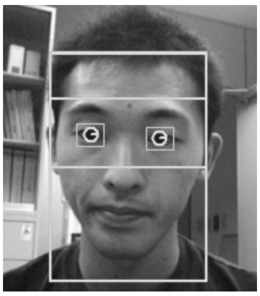


Figure 4. Adaptive limitation of eye regions leaded by previous iris position

Current eye region is compared with previous eye region, and it is evaluated whether the region could include the irises or not.

The evaluation method is follows:

Step1. Calculating the difference between the average gray values in left and right eye regions

Step2. Comparing the difference between left and right Y-axis coordinate value

Step3. Counting the number of pixels of the extracted iris

If the sum of these evaluation values is greater than the threshold, the true irises will not be included in this region.

3 Passive Eye Camera System

3.1 Overview

Person's eye gaze information can be obtained by using the eye movement-tracking device [4], [5]. However, these devices require us to have higher expertise for handling and are very expensive.

Therefore, it is strongly expected to develop a new eye movement tracking device which is not expensive and is easy to use. We introduce such simple image processing system by using a Laptop PC and a Web camera.

3.2 System flow

The system flow is shown in Fig.5. This system captures the image from Web camera, the face region extraction is applied to the image, and the iris is recognized in the face area. Gaze points are acquired by using the series of the center coordinate values provided from the iris recognition.

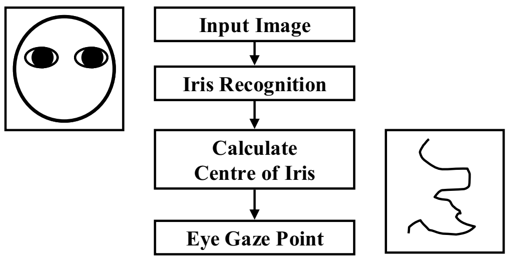


Figure 5. Passive Eye Camera System Flow

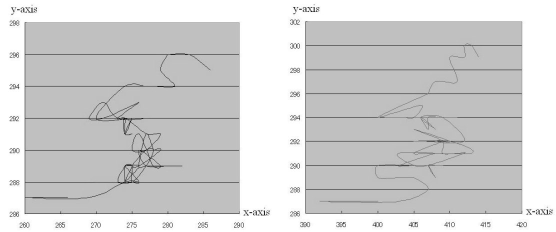
3.3 Experiment and Consideration

Experiment was executed as follows:

E-mail letter shown in Fig.6 (a) with about 15 lines was displayed on the monitor of Laptop PC, Web camera was attached at the top of the monitor, and a person sit at this PC.

Fig.6 (b) and (c) are an example of the eye gaze mark recorded during several seconds. Image processing for iris recognition was implemented by using VGA (640x480) image in this application.

(a) Example of E-mail letter on Laptop PC



(b) right eye mark (c) left eye mark

Figure 6. Result of eye mark pattern that indicates how the testee watches the letter on Laptop PC by using Web camera

It is notable that the eye gaze mark let us know how much carefully he watched the letter and consequently know the non-verbal quality of the verbal E-mail communication. In this example, it is clearly known from these eye gaze patterns that the testee is looking intensively at the body of this E-mail letter.

Although the processing speed of this experiment was about 5 fps, this application could be more realistic by introducing the simultaneous procedures to model the non-verbal quality based on the eye gaze mark.

4 Eye Contact Camera System

4.1 Overview

As shown Fig.7, human is likely to look at the face of his partner on monitor not at camera, he will usually fail to send his own eye-contacted facial images to him.

The basic idea to improve this fatal communication degradation is to regenerate facial image by changing the direction of the irises in the same original facial image.

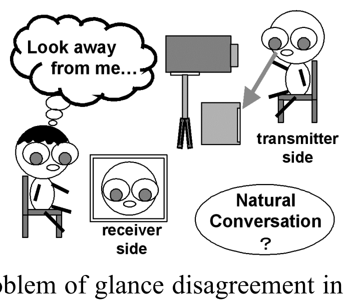


Figure 7. Problem of glance disagreement in VIDEO conference

4.2 Geometric model of the eye contact

In order to model the situation of the VIDEO conference environment shown in Fig.7, the parameters R and r are specified for modeling the vertical relation between the camera and the monitor, and the parameter L is specified for the horizontal relation between them. This is depicted in Fig.8. In the beginning, let us imagine the iris moves from the coordinate (x_0, y_0) extracted before to the new coordinate (x_1, y_1). This new coordinate (x_1, y_1) can be easily calculated by eq.(3) and eq.(4) characterized with the parameters θ_{var} and θ_{hor} indicating the spatial relationship among a person, camera and monitor. In this expression, functions Δx and Δy are designed to convert the parameter θ to the number of the pixels in the facial image.

$$\theta_{\text{var}} = \tan^{-1}\frac{R}{L} \qquad \theta_{\text{hor}} = \tan^{-1}\frac{r}{L} \tag{3}$$

$$\begin{aligned} x_1 &= x_0 + \Delta x(\theta_{\text{var}}) \ : \Delta x(\theta_{\text{var}}) = \frac{\theta_{\text{var}}}{10} \\ y_1 &= y_0 + \Delta y(\theta_{\text{hor}}) \ : \Delta y(\theta_{\text{hor}}) = \frac{\theta_{\text{hor}}}{10} \end{aligned} \tag{4}$$

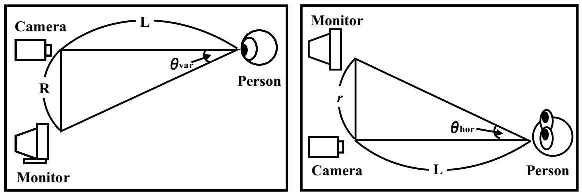


Figure 8. Parameters for modeling the relationship among camera, monitor and human

4.3 Segmentation of the eye region

The centre coordinate (x_1, y_1) and the radius r_1 of the extracted iris are utilized to regenerate the moved iris. Beforehand the eye regions are recognized for utilizing the extracted eye centre coordinate (x_0, y_0). The eye regions (sclera, iris, skin and contour of the eyelid as shown Fig.9) are extracted for both of eyes, and basing on the recognition results, the moved iris is generated within the contour of the eyelid.

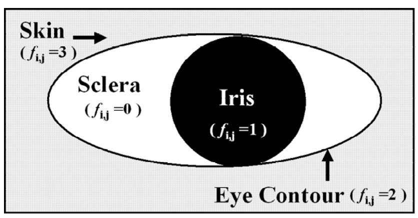


Figure 9. Eye region segment for iris regeneration

4.4 Regeneration of the Irises

The pixels (s, t) in the region for new iris are painted in black at the region where the distance d between (x_1, y_1) and (s, t) is less than or equal to the radius r (as shown Fig.10). All pixels (s, t) within the contour of the eyelid are painted in white at the region where the distance is greater than or equal to r_1. The black and white colors are decided as follows:

$$black = min\ \{F_{ij} \mid f_{ij}=1\},\ white = max\ \{ F_{ij} \mid f_{ij}=0\}$$

(F_{ij} : pixel value, f_{ij} : label number in Fig.6)

After this procedure, smoothing regenerates the irises. The procedure is shown in Fig.11.

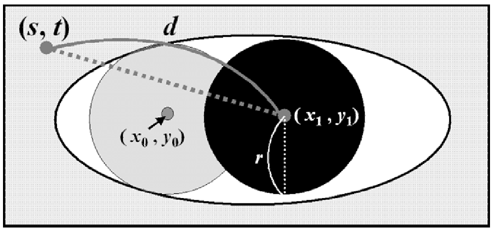


Figure 10. Section of iris regeneration region

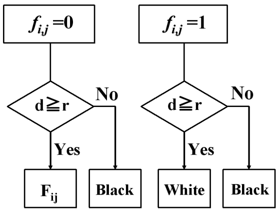


Figure 11. Flow of color selection

4.5 Experiment and consideration

Fig.12 shows the result of the generation of facial image of which eye gaze is contacted to the camera (that is, to his partner).

In this experiment, since the monitor was set at the right side of the camera, his eye gaze was shifted to the left so that his eye gaze came to the position of the camera.

Since the successive relationship among the image frames was not yet implemented in this algorithm, the robustness of this application could be improved by introducing the successive relations among the successive positions of irises.

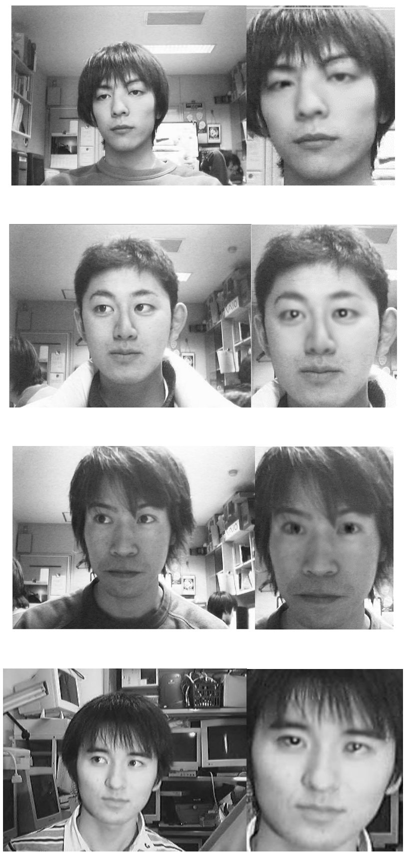


Figure 12. Eye contact image result by iris regeneration

5 Conclusion

In this paper, based on the image processing techniques for the iris recognition, we proposed two kinds of applications for improving the quality of communication: a system of passive eye camera and a system of eye-contacted facial image generation. Through these system developments, we could demonstrate to introduce new facial interface media on the network environment.

As the coming subjects, the proposed systems are now being brushed up so that the real applications could be realized and the recognitions of other facial parts than irises are also being introduced for the complete digital modeling of the face

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