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Mouth and Nostril Detection based on Facial Skin Color Distribution

Bo Peng, Nobuaki Nakazawa, Motohiro Kano

***Abstract*- In this paper, we proposed a new detection method for a face feature point, based on facial skin color,independent of tilted face angles.We picked up the nostril and mouth as a face feature point. Human's face was observed by a camera in real time and the skin color was utilized to detect the face domain. In order to detect the position of nostrils, we focused on the fact that the brightly-colored facial area is distributed around the nostril while the dark-colored facial area is distributed around the eye, the mouth and the jaw.Here we estimated the possibility area of existing nostril by calculating of the red component ratio. Within the estimated area, we detected the nostril position based on the conditionsa) The size of the component is close, b) The inclination of the straight line passing through two points is small, c) Short distance between two points. Furthermore, according to the relative position between the mouth and nostril, the mouth position could be detected. In the test trial, we confirmed that the developed system could detected the nostril and mouth of subject successfully.**

***Index Terms*—Facial skin color, detection,Nostril,Mouth**

I. Introduction

In recent years, the automatic face detection technology [1] has been developed and it has been used on home optoelectronics device, such as digital video recorder, camera, or smartphone, as a matter of course. Such recognition technique has been remarkably developed since the Viola-Jones method [2], [3] and derivative method had been proposed. This method can find a human face from the obtained image very easily. However, it had been constructed on the assumption that a front-facing is roughly kept. Therefore, the side face and large target cannot be recognized, and this method to detect human face is using Haar-like method [4], [5], this method can also detect the human face correctly, but this system has to study about the human face feature point, so the computational complexity is very huge, in this case, it leads to the result that this method needs to study for times and hard to detect the face in real time [6], And many other methods of face detection also have the same problem [7], [8].To solve this problem, the author has proposed a new method of face detection, based on facial feature color [9]. As a same approach, improvements in Viola Jones algorithm using both skin and eyes colors has been proposed to detect the tilted face detections [10]. Here, we used only rough skin color information to detect the nostril position [11]. The proposed system could narrow down the candidate of the nostril by checking the color, area, and aspect ratio, the detection of nostril is proved to be stable of the human face, and according to the relative position of mouth and nostril, we narrowed down the area of mouth detection, and the accuracy rate of the mouth detection has been risen up, this mouth detection method is better than the other methods which just scan the mouth without the other areas of human [12]. After the detection of mouth, we purpose to detect the condition of mouth by setting a threshold, according to this threshold, we can judge that whether the mouth is opened or closed, if the mouth is closed, system will not display, and manipulator will not do any movement, if the mouth is opened, the system will mark the position of mouth in real time.

Bo Peng,Graduate School of Engineering, Gunma Univ.,29-1 Hon-Cho, Oota, Gunma, 373-0057 Japan
Nobuaki Nakazawa, Graduate School of Engineering, Gunma Univ.,29-1 Hon-Cho, Oota, Gunma, 373-0057 Japan
Motohiro Kano, Gunma Industrial Technology Center, 884-1 Kamesato-Machi, Maebashi, 379-2147 Japan

II. Methods

A. Measurement System

Fig.1 shows the procedure flow and constitution of the system disposal. The user's face was observed by the USB camera (Logicool HD Webcam C615). The obtained photograph was converted into bitmap image in real time through the Direct Show. Based on the skin color distribution, face position was extracted to detect the mouth and nostril positions.

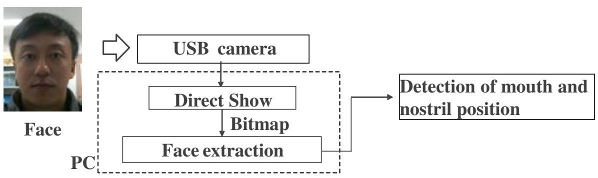


Fig.1 System construction

B. Nostril Position

We proposed a method of face detection based on face skin color [9]. The above paper said that ingredient of R on the skin, nostril, and lips are stronger than other domains.As for these three parts of RGB, the relation of $R > G > B$ was satisfied regardless of brightness. Above all, we could see the differences between R and B remarkably.In addition, we could find that each ratio of RGB color about the skin, nostril, and lips was within certain range.According to the obtained value, the condition to sepatate a pixcel of skin from other facial parts was defined by

$$\tilde{R} < 160, \tilde{G} < 120, \tilde{B} < 90 \quad (1)$$

Where, $(\tilde{R}, \tilde{G}, \tilde{B})$ was a RGB pixel colors. Furthermore, the next condition was required.

$$\tilde{R} < \tilde{G}, 2\tilde{R} < 3\tilde{B}, \tilde{G} > \tilde{B} \quad (2)$$

The above is a magnitude correlation among RGB colors. In addition, the following circumstances among the three color components were also set.

$$\begin{cases} 0.38 < \dfrac{\tilde{R}}{\tilde{R}+\tilde{G}+\tilde{B}} < 0.6 \\ 0.27 < \dfrac{\tilde{G}}{\tilde{R}+\tilde{G}+\tilde{B}} < 0.49 \\ 0.02 < \dfrac{\tilde{B}}{\tilde{R}+\tilde{G}+\tilde{B}} < 0.3 \end{cases} \quad (3)$$

In this research, we use these condition to extract the face position. In order to detect the position of nostrils, we focused on the fact that the brightly-colored facial area is distributed around the nostril while the dark-colored facial area is distributed around the eye, the mouth and the jaw.The evaluation function for the connected part m and n was defined as;

$$e[m,n] = (\alpha|\Delta y/\Delta x| + d)\left(1 - \frac{1}{n}\sum_{j=y_m-n}^{y_m+n} w[j]\right)\left(1 - \frac{1}{n}\sum_{k=y_n-n}^{y_m+n} w[k]\right) \quad (4)$$

Where, the candidate of the nostril was detected by finding the combination of m and n for the minimal value of $e_{\min} = e[m,n]$. α=10, and as shwon in Fig.2, when the face width is x pixel, the occupied ratio for skin color at position y is defined as

$$w[y] = \frac{1}{x}\sum_{i=1}^{x} g[i,y] \quad (5)$$

In addition, the noise was eliminated as shown in Fig.2by smoothing procedure.

The above algorithm was applied to the face domain. The resultof weighting procedure are shown in Fig.3, respectively. The red part expresses the high possibility area for the nostril. Through the weighting procedure, we could see that the skin value was higher around the nostril and mouth compared with any other special feature such as eyes or hair. Next we detect the nostril position within the extracted red part. The feature of the nostril is expressed as follows [9].

- The size of the component is close
- The inclination of the straight line passing through two points is small
- Short distance between two points

Consequently, the two little rectanglesnear the nose in the face area was picked up as a high possibility area of locatingthe nostril.

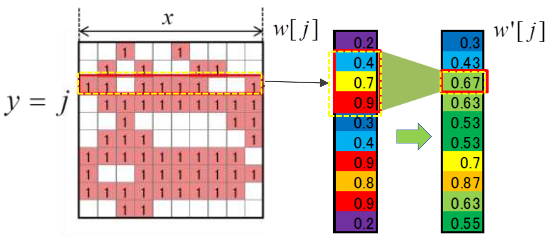


Fig.2weighting procedure

Fig.3WeightingResult

C. *The Detection of Mouth*

Here we propose a new detection method for the mouth position based on the relative position with respect to the nostrils. As shown in Fig.4, we consider the perpendicular bisector of two nostrils. The center point between the two nostrils can be described by.

$$\begin{cases} y_c = (y_{right} - y_{left})/2 \\ x_c = (x_{right} - x_{left})/2 \end{cases} \quad (6)$$

Where, (x_{right}, y_{right}) and (x_{left}, y_{left}) are the position of the right and left nostrils respectively. By using this center point and the straight line formula

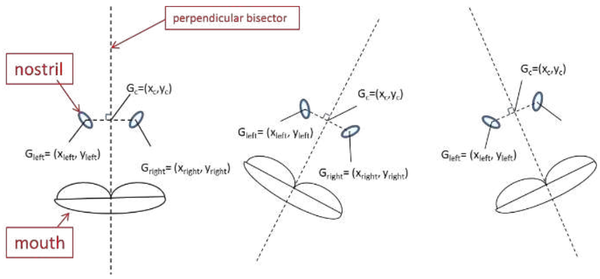
$$y = kx + b \quad (7)$$

And in this case

$$\begin{cases} k = -\dfrac{x_{right} - x_{left}}{y_{right} - y_{left}} \\ b = y_c + x_c\left(\dfrac{x_{right} - x_{left}}{y_{right} - y_{left}}\right) \end{cases} \quad (8)$$

And according to Eq. (6) the perpendicular bisector can be described by

$$y = -\frac{x_c}{y_c}x + \frac{y_c^2 + x_c^2}{y_c} \quad (9)$$



(a)front face (b)tilt to left (c)tilt to right

Fig.4 different direction of face

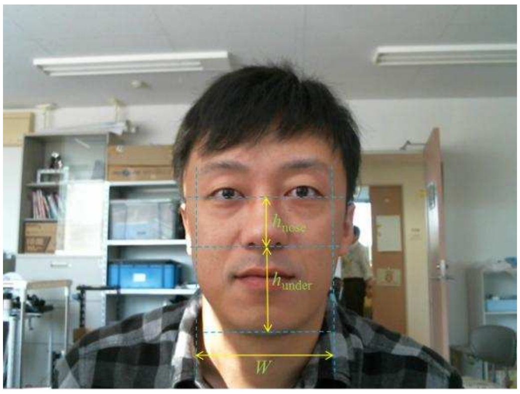


Fig.5 Size of human face

As shown in Fig.5 we use the actually size of human face [13] to determine the area which we search of mouth, according to the data of human face size, the average distance from eyes to the nostrils is $h_{nose} = 53mm$, the distance between nostrils and chin is $h_{under} = 71.4mm$, and the wide of mandible is W = 109.6mm.

So in our system, we detect the distance between eyes and nostril as $\tilde{h}_{nose}$ in real time, and according to the proportion between these h_{nose} , h_{under} , and W, the $\tilde{h}_{under}$ and $\widetilde{W}$ which we use to calculate the area of mouth detection will be work out by the formula below,

$$\begin{cases} \widetilde{W} = \dfrac{W}{h_{nose}} \tilde{h}_{nose} \\ \tilde{h}_{under} = \dfrac{h_{under}}{h_{nose}} \tilde{h}_{nose} \end{cases} \quad (10)$$

After we calculate the area of the mouth, we reduce this area by experience below the nostril by α and β in W sides as shown in Fig.6

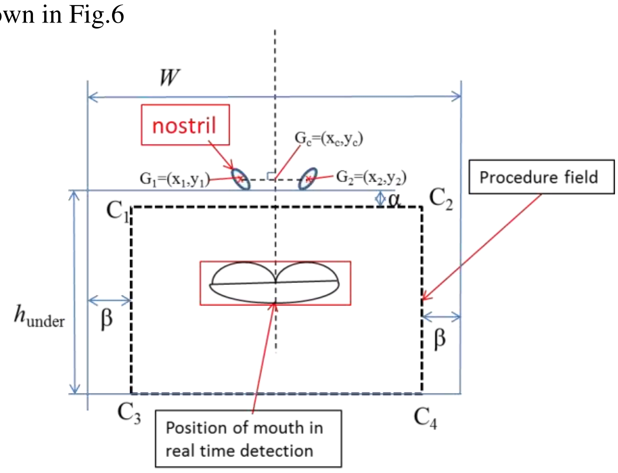


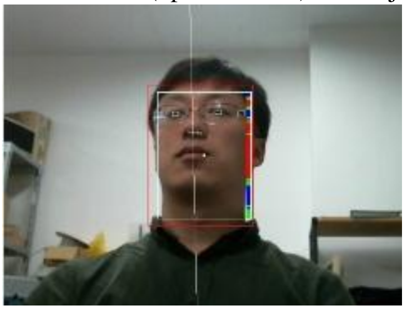
Fig.6 detection of mouth area

And the detection area rectangle $C_1C_2C_3C_4$ can be calculated by the formula below

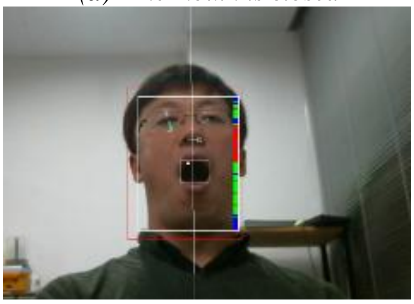
$$\begin{cases} C_1(x_1, y_1) = \left(x_c - \frac{W}{2} + \beta, y_c + \alpha\right) \\ C_2(x_2, y_2) = \left(x_c + \frac{W}{2} - \beta, y_c + \alpha\right) \\ C_3(x_3, y_3) = \left(x_c - \frac{W}{2} + \beta, y_c + h_{under}\right) \\ C_4(x_4, y_4) = \left(x_c + \frac{W}{2} - \beta, y_c + h_{under}\right) \end{cases} \quad (11)$$

D. Verification Experiment

In the verification experiment we try to detect the position of the mouth by our constructed system. Fig.7 (a) and (b) show the condition when the mouth is closed and opened, respectively. The As shown in Fig.7 (a), when the area of the mouth is small than the threshold set, the rectangle around the mouth wasn't displayed, on the other hand, as shown in Fig.7 (b) when the area of mouth is larger than the threshold set, the rectangle around the mouth appeared. So the result shows that the system can detect the mouth position correctly, and the condition of the mouth (open or close) can be judged.



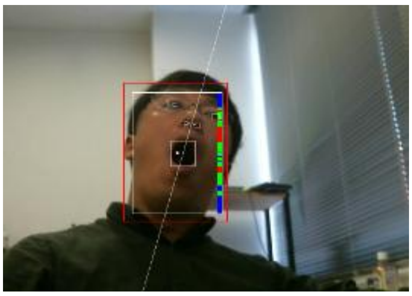
(a) The mouth is closed



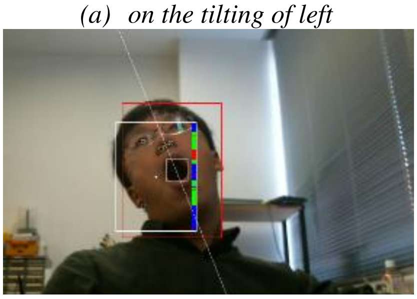
(b) The mouth is open

Fig.7 result of verification experiment

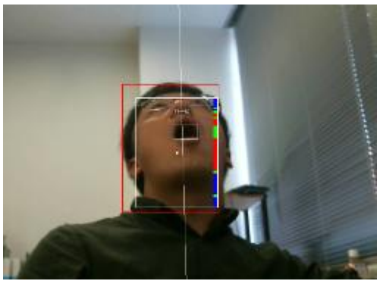
Next, we consider the condition of face posture, tilting, upward, and head drop. As shown in Fig.8 (a) ~(c), the system can detect the mouth when the head is tilting to the left and right. If the face is upward, the system can also recognize the mouth position correctly. But when the face is directed to the downward, the system doesn't display the rectangle as shown in Fig.8 (d) because it's difficult for patient to swallow food when the head direct to the downward, in order to avoid dysphagia, this system does not display mouth position when the body is in inappropriate posture.



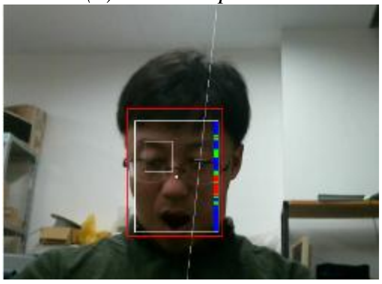
(a) on the tilting of left



(b)on the tilting of right



(c) on the upward



(d) on the head drop

Fig.8 different condition of face posture

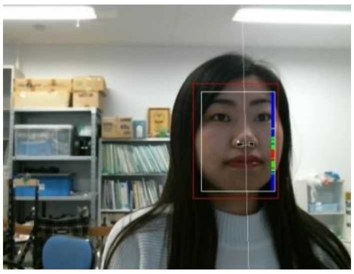
Next, we carried out the experiments by multiple subjects. Twelve subjects (ten men and two women) participated in the experiment. We confirmed the detection of face, nostril and mouth under the condition that the USB camera was located in front of the subject. The subjects were directed to open the mouth. Moreover, we carried out the same experiment in cases where the camera was in the left and right side of the subject. The experiment results are shown in Table.1, the circle mark means successful detection, and the triangle mark means that detection was failed. Some example images of the detection are shown in Fig.9. As shown in this figure, the color of skin is different among the subject and the brightness of skin is also changed according to the face direction with respect to the celling light. Regardless of this condition, the results of Table.1 says that the system could detect all subject faces. As for the nostril, no matter what shape and area the two nostrils were, the nostril of all subjects could also be detected. Furthermore, the mouth open state of all subjects were recognized and the rectangle around the mouth consequently appeared. In the side detection, the mouth could be detected in most conditions, but the mouth of subject "I" couldn't be detected accurately in two cameras. The subject "I" has the thick beard shown in Fig.9 (g) and (h). However, it is possible to solve this problem by moving the position of the camera to the front of the subject.

From the above results, we considered that the system is enough to detect the mouth position and open/close states and applied it to the manipulation of meal support equipment.

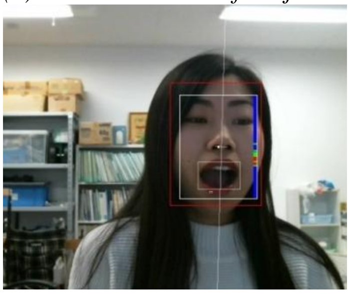
Table.1 Experimental examples

Subject	Face	Nostril	Mouth	Left side	Right side
A	○	○	○	○	○
B	○	○	○	○	○
C	○	○	○	○	○
D	○	○	○	○	○
E	○	○	○	○	○
F	○	○	○	○	○
G	○	○	○	○	○
H	○	○	○	○	○
I	○	○	○	△	△
J	○	○	○	○	○
K	○	○	○	○	○
L	○	○	○	○	○

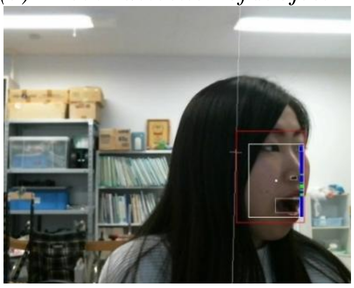
○ Detected △ Fail



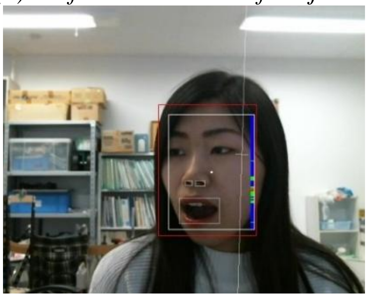
(a) Front detection of subjectK



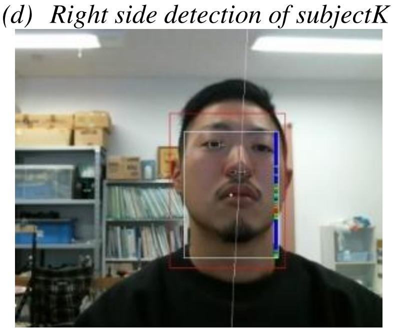
(b) Mouth detection of subjectK



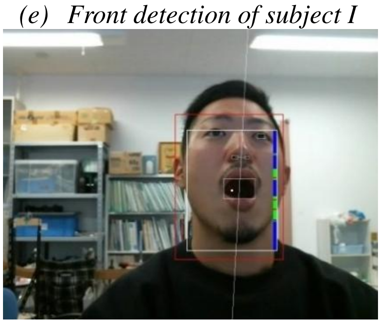
(c) Left side detection of subjectK



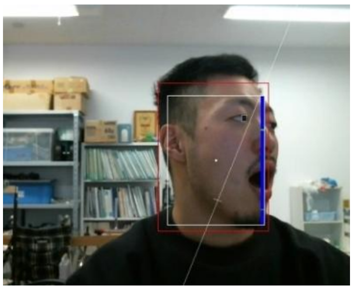
(d) Right side detection of subjectK



(e) Front detection of subject I



(f) Mouth detection of subject I



(g) Left side detection of subject I

(h) Right side detection of subject I
Fig.9 Result example of face detection

III. CONCLUSION

In this paper, a new detection method for a face features point was proposed by using facial skin color, independent of tilted face angles. We chose the nostril and mouth as a face feature point. We observed human's face by a camera in real time and utilize the skin color to detect the face domain. By the purpose of detect the position of nostrils, we paid attention to the fact that the brightly-colored facial area is distributed around the nostril while the dark-colored facial area is distributed around the eye, the mouth and the jaw. Here we estimated the possibility area of existing nostril by calculating of the red component ratio. Within the estimated area, we detected the nostril position based on the conditions a) The size of the component is close, b) The inclination of the straight line passing through two points is small, c) Short distance between two points. Furthermore, according to the relative position between the mouth and nostril, the mouth position could be detected. In the test trial, we confirmed that the developed system could detected the nostril and mouth of subject successfully. As the future work, we will use this system to develop the meal support equipment.

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