Automatic Face Identification System Using Adaptive Face Region Detection and Facial Feature Vector Classification

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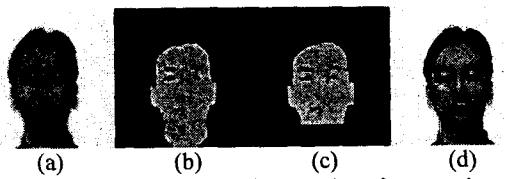
Abstract: In this paper, face recognition algorithm, by using skin color information of HSI color coordinate collected from face images, elliptical mask, features of face including eyes, nose and mouth, and geometrical feature vectors of face and facial angles, is proposed. The proposed algorithm improved face region extraction efficacy by using HSI information relatively similar to human's visual system along with color tone information about skin colors of face, elliptical mask and intensity information. Moreover, it improved face recognition efficacy with using feature information of eyes, nose and mouth, and Θ1(ACRED), Θ2(AMRED) and Θ3(ANRED), which are geometrical face angles of face. In the proposed algorithm, it enables exact face reading by using color tone information, elliptical mask, brightness information and structural characteristic angle together, not like using only brightness information in existing algorithm. Moreover, it uses structural related value of characteristics and certain vectors together for the recognition method.

1. Introduction

As visual processing area using computers are getting advanced, studies related to human's bio-signal or visual system are in progress. Specially, studies about recognition of face, gesture and movement of human's face into animation are actively being performed. Moreover, as security related fields are considered important with development e-commerce, face recognition part has various uses and application range as well as being one of studies, which are most actively studied on. Information we can extract from face can be used at various fields, such as criminal search system, restriction of using personal computer, security system at public organizations, computer game, viewer search system of 3D TV and many others. Procedures of face recognition may be divided into three steps as whole face region detection, facial feature detection and face recognition. Namely, it detects face region and extracts constituent features like eyes, nose and mouth [1,3]. At last, it performs the last level, classification and recognition. However, current technology has restrictions with direction, color, brightness, races and other outer components. This paper detected primary face region candidate with using hue information of HSI coordinates to improve accuracy level in detecting face region. It also improved detection accuracy by allowing it to detect face region with intensity value, edge information, and elliptical mask. Moreover, it improved recognition efficiency by applying method using geometrical relation value, facial feature vectors, and four facial angles.

2. Face Detection Using Color, Intensity, and Ellipse Mask

In face color chromaticity, people in same race have similar face color and they are massed around small range of color field [2]. In this paper, we used hue and intensity value from HSI color coordinate relatively similar to human's visual system to detect face region. For primary candidate face region, convert input color image into HSI color coordinates to get skin color tone information, and come up with labeling formula of massed objects by using hue value of skin color, and then the largest object among messed objects at certain range becomes candidate face region. From many standard image tests, primary candidate face region was very variable according to the hair, neck and clothes put on and the region showed the tendency of getting larger. Therefore, in this proposed paper, we detected face region by searching within the primary candidate face region range, and applying intensity value distribution, edge information and elliptical mask higher than the adaptively calculated threshold value of skin color information. Fig. 1 shows the procedure of detecting face region.



(a) (b) (c) (d)

Fig. 1 The procedures of detecting face regions: (a) Original image; (b) Candidate face region (c) Face region (d) Ellipse masked image.

In Figure 1, Fig.1(b) is the image of candidate face region having similar distribution of skin color tone and intensity. Fig.1(c) is the face region image using skin color, intensity and edge information and Fig.1(d) is the image applied elliptical mask to marked face region in test image by using coordinates value from the elliptical face region[6].

Recognition computation and efficiency was improved by separating facial region from whole image to detect face region, and using calculated elliptical coordinate values of constituent objects, such as eyes, nose and mouth. In this paper, we measure skin color value based on the mongolian and also enabled face recognition by races with providing calculate HSI value for the caucasian and Negroid race. Fig. 2 shows the process of detecting face region for the races. And also, Table 1 shows the skin color coordinates for the races, which acquired for the test sample images.

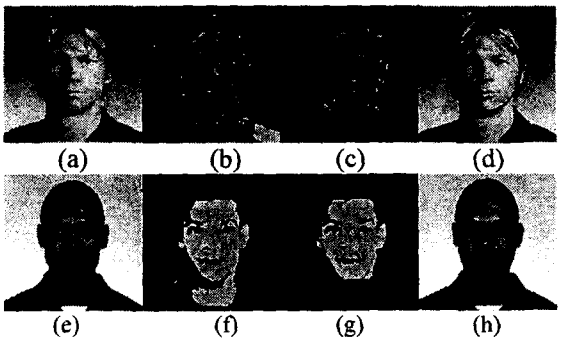


Fig 2. Face detection process. (a) Caucasian image; (b) Candidate face region of image(a); (c) Face region of image (a); (d) Ellipse masked image of image (a); (e) Negroid image; (f) Candidate face region of image(b); (g) Face region of image (b); (h) Ellipse masked image of image (b).

Table 1 Color coordinate value(8 bits)

Coordinate	H	S	I
Caucasian	27	163	210
Mongolian	23	170	179
Neogroid	20	198	106

As shown in Table 1 from the HSI color coordinates by races, the caucasian race has the largest hue and intensity value. Among 226 male/female standard images used for the study, images detected exact face region and removed areas other than that were 216, which showed face region recognition rate of 95.5%.

3. Detecting Facial Feature Vectors of Eyes, Nose and Mouth.

In this paper, intensity image of images converted into HSI coordinates to prepare detecting geometrical features of face is used. Geometrical feature detection is completed with applying horizontal Sobel operator, binary, dilation, labeling[3] based on the fact that facial characteristic aspects have many horizontal edges.

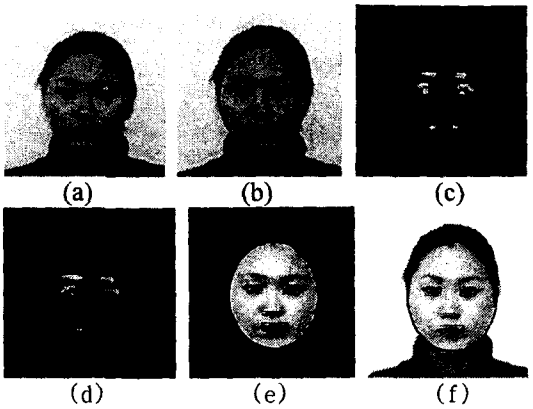


Fig 3. Pre-processing and facial of Feature detection results: (a) Original image; (b) Face region image with ellipse masking; (c) Binary image; (d) Dilated image; (e) Labeled image; (f) Facial feature image.

Fig.3 shows the procedures of detecting features of eyes, nose and mouth through the preprocessing process. For the algorithm determining features of eyes, nose and mouth through preprocessing, we used relative geometrical position of both eyes and nose to determine two candidate eye position and one candidate nose position and one candidate mouth position having similar vertical axis coordinate. When following conditions are satisfied, set them in a pair as eyes within the area and the distance ratio is considered as a characteristic.

-Condition 1) The object stands on horizontal center line and also stands within symmetric y coordinate.
-Condition 2) If symmetric pairs are more than two, there should be a symmetric pair, which is located at lower position and has distance lower than the critical value.

Set an object qualified for following condition as candidate nose position and consider the distance rate as a characteristic.

-Condition 1) When it is located at lower than candidate eye area and at between them, and when difference in y coordinate is lower than critical value.
-Condition 2) If there are several qualified objects, select one located at higher position.

Set an object qualified for following condition as candidate mouth position and consider the

distance rate as a characteristic.

-Condition 1) When it is located at lower than candidate nose position and at outside of both eye coordinate.

-Condition 2) If there are several qualified objects, select one with horizontal distance rate is high and located at higher position.

Among 226 male/female standard images used for the study, images detected exact characteristics of eyes, nose and mouth were 216, which showed face area recognition rate of 93%.

4. Face Recognition with Geometrical Feature Vectors and Facial Angles

4.1 Constitutions and Face Features of Eyes, Nose and Mouth Characteristics

Calculate geometrical position value of related object from coordinates of face feature candidate region. Each face feature vector can easily be identified from face and each person shows differences with it. For comparison of these each face feature vector, the value, which compared relationship among geometrical positions of eyes, nose and mouth, is used.

In this paper, error in rate was lowered by using position of mouth, nose and eyes, and average value of lowest/highest value among them. Distance rate between characteristic points are calculated with Euclidean distance formula. Recognition with Euclidean distance formula (1) is normalized with standard deviation (σ). In formula (1)~(3), i is feature index, r_i is feature value of database, x_i is feature value of test image, m is number of DB image, and N indicates the image number of objects being recognized.

$$d^2 = \sum_i |X_i - r_i|^2 \quad (1)$$

$$d^2 = \sum_i \frac{|X_i - r_i|^2}{\sigma_i^2} \quad (2)$$

$$\sigma^2 = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{1}{m}\sum_{k=1}^{m}\left(r_{ijk} - \frac{1}{m}\sum_{k=1}^{m} r_{ijk}\right)^2\right) \quad (3)$$

From the result face feature information, we suggest facial feature vectors such as D_{eye}, D_{nose}, D_{mouth}, D_{cheek}, $D_{eye\text{-}nose}$, $D_{mouth\text{-}chin}$, $D_{nose\text{-}mouth}$, and $D_{cheek\text{-}chin}$. Fig. 4 shows the facial feature vectors of face region to classify and recognize input face image. And also Equation (4) represent facial feature vector extraction formula.

$$F_{type} = \frac{1.2 D_h}{D_v}$$

$$C_{type} = \frac{1.2 D_{eye}}{D_{eye-nose} + D_{nose-mouth}} \quad (4)$$

$$D_{eye} = D_{lefteye} + D_{righteye}$$

$$D_{eye-nose} = Abs\,(D_{eyecenter} - R_{nose})$$

$$D_{nose-mouth} = Abs(R_{nose} - R_{mouth})$$

$$D_{mouth-chin} = Abs(R_{mouth} - R_{chin})$$

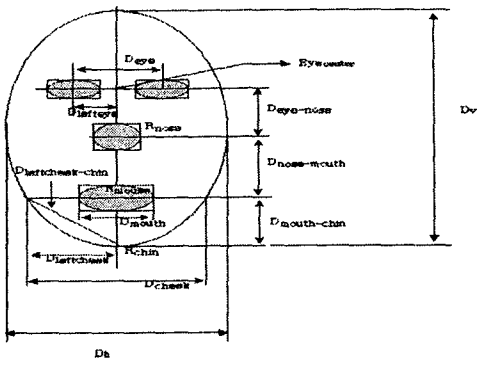


Fig 4. Facial features vectors of face region

4.2 Calculating Facial Angles with Geometrical Relationship of Features

Face recognition algorithm is proposed by including geometrical relation value of face features, relative extracted facial feature vectors and three facial angles. Geometrical relation value of facial features is an algorithm using geometrical position value of eyes, nose, mouth and chin in face region, and facial angle of chin reference to eye distance, mouth reference to eye distance, and nose reference to eye distance.

Following Fig. 5 shows the geometrical facial angles and equations(5)~(7) are formulas for calculating facial angles from the facial features of face region.

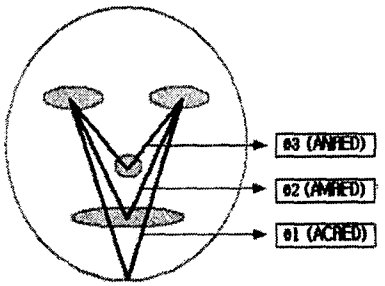


Fig 5 Geometrical facial angles.

$$COS\,\theta_1 = \frac{D_{LCE-C}^2 + D_{RCE-C}^2 - D_E^2}{2 D_{LCE-C} D_{RCE-C}} \quad (5)$$

$$\left(D_{LCE-C} = D_{lefteyerighteye-chin}, D_{RCE-C} = D_{righteyelefteye-chin-chin}, D_E = D_{eye}\right)$$

$$COS\,\theta_2 = \frac{D_{LCE-M}^2 + D_{RCE-M}^2 - D_E^2}{2 D_{LCE-M} D_{RCE-M}} \quad (6)$$

$$\left(D_{LCE-M} = D_{lefteyerighteye-mouth}, D_{RCE-M} = D_{righteyelefteye-mouth}, D_E = D_{eye}\right)$$

$$COS\,\theta_3 = \frac{D_{LCE-N}^2 + D_{RCE-N}^2 - D_E^2}{2 D_{LCE-N} D_{RCE-N}} \quad (7)$$

$$\left(D_{LCE-N} = D_{lefteyerighteye-nose}, D_{RCE-N} = D_{righteyelefteye-nose}, D_E = D_{eye}\right)$$

where θ_1 is the angle at the center of both eyes from the center of chin, θ_2 is the angle of the center of mouth and both eyes and θ_3 is the angle of center of nose and eyes. For classifying and recognizing face image, facial angular difference of cosθ1, cosθ2 and cosθ3, determined from the calculating the rate of θ1, θ2 and θ3 is used. Table 2 shows geometric facial angle of features from θ1, θ2 and θ3, which are considered as classification criterion in this paper. This distribution is divided into three geometrical types such as A, B, and C type. And also, Fig. 8 show the resulting images for three facial angles on real images. We could notice that geometrical features and relation value of features may show some differences with people.

Table 2. Classification types for facial angles

Type	A type	B type	C type
θ1	30°~34°	34°~40°	40°~45°
θ2	44°~47°	47°~50°	50°~53°
θ3	59°~64°	64°~69°	69°~74°

(a)A type (b)B type (c) C type

Fig 6. Type A, B, C Based on Facial angles

5. Experimental Results

In this paper, not complicated background and fixed lighting were restricted for experiment environment. For accurate and reliable sampling of face region, various steps were applied successfully. Among 226 male/female standard images used for the extraction of face feature vectors and facial angles. Figure 7 shows facial angle by classifications using face region and its feature vectors with real image. Fig. 7(a) is the image, extracted facial features from face image, and Fig. 7(b) is the result image describing facial angle of face features.

(a) (b)

Fig 7. Result image for facial feature extraction and facial angles; (a) Resulting image for facial features; (b) Resulting image for facial angles.

Table 3 shows the result of applying proposed algorithm for sample images. As you can see in this table, there was many Type B. Among 216 face region images used for the detection of facial featres, images detected exact features of face were 208, which showed face feature extraction rate of 96.3%. And, Fig. 8 shows the GUI of automatic facial identification algorithm.

Table 3. Detection and recognition results for proposed algorithm.

Process	Face Detection	Feature Detecte	Recognition	Total Image
Image	216	208	197	226
%	95.5%	92%	87.2%	100%

Fig 8. GUI of automatic facial identification algorithm.

6. Conclusions

In this paper, face recognition algorithm, by using color information, elliptical mask, features of face and facial angles, is proposed. In the proposed algorithm, we have improved the face recognition rate as well as the face region detection rate. For securing enough data, solving problems related to face recognition and identification process and embodying system for real time application, adaptive method should be studied and proposed.

References

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