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AUTOMATED FACE DETECTION AND FEATURE EXTRACTION USING COLOR FERET IMAGE DATABASE

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Abstract—**Detecting the location of human faces and then extracting the facial features in an image is an important ability with a wide range of applications, such as human face recognition, surveillance systems, human-computer interfacing, biometric identification, etc. Both face detection and face features extraction methods have been reported by the researchers, each with a separate process in the field of face recognition. They need to be connected through adapting the face detection results to be the input face in the extraction process by turning the minimum face size results from the detection process, and the way of face cropping process from the extraction process. The identification and recognition of human face features that has developed in this research is the combination of face features detecting and extracting process in 150 frontal single still face images from color FERET facial image database with additional extracted face features and face features' distances.**

***Keywords-** face detection, face extraction, face features, face recognition, feret*

I. INTRODUCTION

Biometrics encompasses automated methods of recognizing an individual based on measurable biological (anatomical and physiological) and behavioral characteristics. As a biometric, facial recognition is a form of computer vision that uses faces to attempt to identify a person or verify a person's claimed identity [1]. Facial recognition systems are more widely used than just a few years ago. Most of the pioneering work in face recognition was done based on the geometric features of a human face [2]. Detecting the location of human faces and then extracting the human face features in an image is an important ability with a wide range of applications, such as human face recognition, surveillance systems, human computer interfacing, video-conferencing, etc [3].

Detecting human faces and extracting the facial features in an unconstrained image is a challenging process. There are several variables that affect the detection performance, such as different skin coloring, gender, and facial expressions. One of the researches in face recognition system is face image detection from a single still image where the face image part is detected by skin color model analysis [4], [5]. The determination of face region in the research was not complete, because some parts of the face were not included in the extraction process. If one component of face features is detected, the position of other components would be obtained and the component could be extracted. Other research in face recognition system is the face features extraction which has obtained eye and mouth region and the distances between eye and mouth [6]. In this paper, based on those researches, we develop a system that separates a face image into face components, and then extracts components in the regions of eyes, nose, mouth, and face boundary from a frontal single still face images from color FERET facial image database with additional extracted face features and face features' distances.

II. METHODOLOGY

The techniques in image processing that is used in face recognition are varied [7], yet they have the same three basic stages, as illustrated in Fig. 1. First, the system gets the input of an image. Then, the system will detect the face region. After that, it will extract the face image in order to get the face features, for instance eye, nose and mouth. Finally, the system uses the detected face image to obtain the information of each face feature that has been extracted.

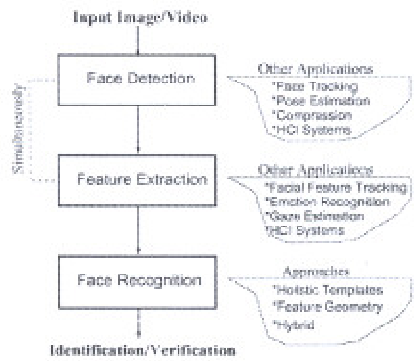

Figure 1. Configuration of a generic face recognition system.

A. Face Detection Process

In this paper, the 150 frontal face images from color FERET facial image database will be processed in order to do the automated face recognition process. Fig. 2 shows the frontal single still face images from color FERET facial image database. The first step is face detection based on skin color model. A skin color model which has represented the human skin color is made for the segmentation of skin region and non-skin region in color images. The size of the input of face image is used for this research object is 300x350 pixels in JPG format. The image with RGB format will be converted to YCbCr format in order to eliminate the light effects. Decreasing the luminance level is conducted by image conversion from RGB to YCbCr or chromatic color. After the Cb and Cr values are obtained then the low pass filter is conducted to the image in order to reduce noise. The reshape function is next applied to Cb and Cr values which turn them into row vectors. Ninety row vectors are formed from each Cb and Cr values. All components of Cb become Cb vector elements, and all Cr components become Cr vector elements. The vector results of Cb and Cr are used to find Cb average value, Cr average value, and covariance of Cb and Cr.

Figure 2. The frontal single still face image.

Face detection process begins with skin model detection process by applying the threshold value. The threshold is the process of separating pixels which have different gray level. The value of a pixel that has a lower gray level from the boundary value will be changed into 0, and the value of a pixel which has a higher gray level will be changed into 1. Threshold is needed to transform the element of pixel in the test images into binary images.

B. Face Cropping Process in a Single Still Image

The binary image, obtained from the threshold process, is further processed to take and crop the face region of the image. The face image is the region in white color or pixel value = 1. This process goes through the following steps [2]:

1) Separating the face skin region from those of the non-face region, such as neck.

2) Determining holes of the face, as there must be one hole from the image that belongs to the face region. The number of holes in face region is computed with the following equation:

$$E = C - H \tag{1}$$

Where E is Euler number, C is related component number and H is hole number in the region.
By using this equation, the value of H can be found by calculating H = 1 – E, to obtain the skin region of the face.

3) Finding the statistic of color value between the hole area of the picture (which indicates the face area) and the face template picture after the hole that represents the face region has been determined. The following equations are used to find the center of mass in determining the face part position of the picture:

$$\bar{x} = \frac{1}{pic\_area} \times \sum (row\_el \times pic\_el) \tag{2}$$

$$\bar{y} = \frac{1}{pic\_area} \times \sum (col\_el \times pic\_el) \tag{3}$$

This process uses a different face template from the one in Rademacher's research. Rademacher used the face template as shown in Fig. 3, while the improved template which is used in this research, is shown in Fig. 4. The fundamental differences between these two templates are the face position in the whole template and the size of black region around the image. In the previous template, the forehead and chin region were eliminated. This research uses those regions to determine the successful of the feature extraction. Moreover, the face position in Rademacher's template was not symmetric. It can affect the final result because it will reduce the symmetric face region which has been obtained. The difference of face skin color in the template has no significant effect to the face result obtained through this process.

Figure 3. Rademacher's template.

Figure 4. Face improved template.

4) The previous process gives the result of an image that contains a human face, has at least one hole after the analysis process or has a width to height ratio of approximately 1. The angle of the centre of mass that contains the face region is determined by using the centre of mass of the face object's position. The following equation is used to find such angle:

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$$\theta = 0.5 \tan\left(\frac{b}{a-c}\right) \quad (4)$$

Where

a = ΣΣ (x') * 2 * pic_el

b = 2 ΣΣ (x') * ΣΣ(y') * pic_el

c = ΣΣ (y') * 2 * pic_el

$x' = x - \bar{x}$

$y' = y - \bar{y}$

Every step is conducted based on the numregion or the er of regions with color value of 1 in the binary image. If th to height ratio is between 0.6 and 1.2 is obtained, the :nted area is assumed to be a face region, and its inates are saved in a row vector.

The coordinate values are used to form a rectangle is surrounding the face (bounding box) in the image.

The bounding box, which is the face region, is ıted with the original image using the cropping process. :sult of the face cropping process can be seen in Fig. 5.

Figure 5. The result of face cropping process.

ıce Extraction Process and Measurement of Face :atures' Distances

this paper, the 150 frontal face images from color Γ facial image database will be processed in order to do. ce region image as a result of face detection process is · processed to obtain the face components and the :es between them. This is conducted by extracting the ıose, and mouth components. The extraction determines mponents' locations, and is done on YCbCr color space arate the luminance and chrominance components in to reduce the lighting effect. There are 8 component :es measured [10].

: face extraction process in this research is conducted in tages:

Face division.

Face features detection and extraction.

Measurement/ calculation of distances between face features.

: face image, which the face features will be extracted, is ;ed by dividing it into regions, in order to narrow down a for the detection. So, the extraction result can be more :e and it can minimize the probability of other face s detected. The detection is conducted by computing the components of color space in regions assumed to be the locations of face features. After that, the regions that are assumed to be the locations of face features are extracted to determine the location of the features. In this research, there are four steps to do the extraction of face features. The first is the face division. The second is the extraction of eye feature. The third is the extraction of nose features. And the last is the extraction of mouth feature.

1) Face Division in The Face Image : The face division is divided into three parts, which are face region, eyes region, and mouth regions. The face image that can be processed must have the forehead and chin regions as a minimum requirement, and the neck region as the maximum requirement. The face division is meant to detach the detection area among eye and mouth features. The face division is based on assumption as follows:

- Both eyes regions always reside in the upper half of face region
- The mouth region always resides in the undercarriage half of face region

This division is conducted while a face image is assumed as the result from face detection process. Next, the eye region resulted from the face region division that has been divided. The aim of this division is to narrow the possibility area of right eye and left eye location reside and then separate them, based on assumption:

- Half of upper eye area is eyebrow/ forehead
- Half of lower eye area is the location/ position of the right and the left eye
- The position of eyes is assumed symmetrically, right eye reside in half of right shares and left eye reside in half of left shares of face.

In this research, some improvements are done on the mouth region to get better result from the previous research. The former research divided the mouth region as illustrated in Fig. 6.

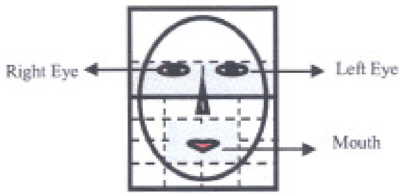

Figure 6. Previous mouth region division.

An approximate position of the mouth was determined as the centre of the region, vertically and horizontally. While, the mouth feature in this research is not always located vertically at the centre of the region, as there exists a neck region that affects the mouth feature position in the mouth region. This is

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illustrated in Fig. 7. The divisions of face image consider the image size and use the criteria of division that explained previously.

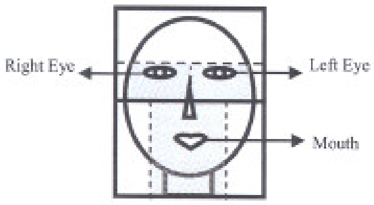

Figure 7. Improvement in mouth region division.

2) Face Component Detection and Extraction

After the cropping process, the feature extraction is conducted as follows [8]:

a) The eye extraction is done by forming an eye map. The eye map is formed from chrominance components which is based on the high Cb value and the low Cr value, that is found around the eye region, and also the luminocity component that is based on the eye region which is composed of the combination of light pixels and dark pixels.

b) The mouth extraction requires chrominance components (Cr dan Cb) which contains more red components than blue components. It means the mouth region contains more Cr component values than Cb component values. The mouth region has low respons to the Cr/ Cb components, yet it has high respons to Cr^2 components. So, the quarrel between Cr^2 components and Cr/ Cb components can be clarified the mouth region, and then it can form a mouth map.

c) In previous research, nose extraction is conducted after the distance between left and right eyes' midpoints is determined [9]. Nose height and width is determined as shown in Fig. 8.

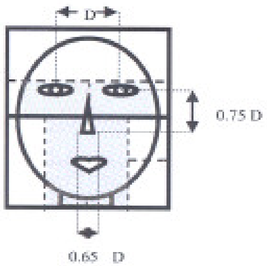

Figure 8. Nose feature geometry.

The following equations compute the nose's size:

$$\text{Nose\_height} = 0.75 * v \tag{5}$$

$$\text{Nose\_width} = 0.65 * l \tag{6}$$

Where v is vertical distance between two eyes and nostril; l is vertical distance between two eyes.

d) Nostril extraction is done after the nose can b extracted and the nose region is further divided into parts obtain the nostril specific area. The division results in:

- Nose upper part
- Nose lower part, which consists of: lower right pa lower middle part, lower left part.

e) Nose lower middle part is the nostril specific area. B mapping this area, the nostril is obtained. This nostril will a as a reference for measurement to and from the nose. After th whole extraction process is finished, each feature surrounded by a box, except for the nostril which is marked b a dot. The result is shown in Fig. 9.

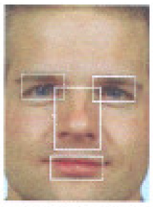

Figure 9. The extraction face features result.

3) Measurements of Face Features' Distances

The distances between each face features are distances fro certain points in every feature box, which are:

- The midpoint of right eye box.
- The midpoint of left eye box.
- The midpoint of mouth box.
- Nose peak.
- End points of nose width.

All distances between face features mentioned earlier a obtained from these five points. The face distanc computation is done by calculating the difference betwe every row or column point's coordinates if there exists perfect vertical/ horizontal line connecting those poin Otherwise, the Pythagoras theorem is used, since addition lines can be drawn from the coordinates to form a rig triangle. Face feature distance is obtained from the diagon side of the right triangle. The value, which is in decimal form is rounded to the nearest integer. Distances between fa components used in this research are the ones between left right eye, right eye - mouth, left eye - mouth, right eye - nos peak, left eye - nose peak, mouth - nose peak, nose heigh nose width (as described in previous section).

The distances' combination forms the semantic that represe the uniqueness of face components.

- D1 = right eye - left eye distance
- D2 = right eye - mouth distance
- D3 = left eye - mouth distance

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D4 = right eye - nose peak distance

D5 = left eye - nose peak distance

D6 = nose peak - mouth distance

D7 = nose height

D8 = nose width.

III. Experimental Results

section will describe about the results of face on system. In this research, 150 frontal single still ges from color FERET facial image database are ing the face recognition application. The images in r FERET Database were originally processed onto PhotoCD's. Then the PhotoCD-format images were d into PPM-format using the program "hpcdtoppm". images have been taken with relatively different condition, color background, yet the distances from ured object of each image were relatively the same. mages are converted into JPEG format with 300 x 350 solution of RGB colors.

r distances between each face features are obtained, system checks the uniqueness of the distances face features. It can be done by checking the ss of the entire data of face features' distances which 8 distances (D1-D8). Then, the system checks the ss of 7 distances (D1-D7), then 6 distances (D1-D6), istances (D1-D7), and so on. The data, that is not by the system for checking the uniqueness, is the last face feature distances. So, if the system check the ss of 8 distances, it will check from D1 (right eye - distance) up to D8 (nose width), then if the system he uniqueness of 7 distances, it will check from D1 e - left eye distance) up to D7 (nose height), and so on system check the uniqueness of 1 distance, D1 (right t eye distance) for each image. The result can be seen 1.

I. The uniqueness level of face features' distances

Component Distance Combination	Unique Number	Unique %
D1-D2-D3-D4-D5-D6-D7-D8	150	100,00
D1-D2-D3-D4-D5-D6-D7	150	100,00
D1-D2-D3-D4-D5-D6	150	100,00
D1-D2-D3-D4-D5	150	100,00
D1-D2-D3-D4	150	100,00
D1-D2-D3	148	98,66
D1-D2	127	84,66
D1	7	5,00

uniqueness of face feature's result shows that the equires minimum 4 distances of face features or more, to get the uniqueness of face features' distances. The of facial features's distances that used in the system proportional minimum to the amount of test face get a list of unique distances because the uniqueness feature is influenced by a number of possible combinations of the entire facial features values to the whole data.

As the process of checking the uniqueness of 8 distances, if it is assumed one distances of face feature consists of two-digit, the combinations of those 8 distances (D1-D8) are (10^{16}-1) in 150 data records. While, if the face feature consists of 4 features and the distances of face feature consists of two-digit, the combinations of face features are (10^{8}-1). It can decreased the number of possible combinations of face features' distances.

IV. Conclusion

The identification and recognition of human face features that has developed in this research is the combination methods of face features detecting and extracting process, by shifting the minimum face image that is used as standard input for the extraction into face image with forehead and chin, and revising the cropping process of extracted face region, in frontal single still face images with additional extracted face features and face features' distances. The number of facial features's distances that used in the system must be proportional minimum to the amount of test face image to get a list of unique distances because the uniqueness of face feature is influenced by a number of possible combinations of the entire facial features values to the whole data. The uniqueness of face feature's result shows that the system requires minimum 4 distances of face features or more, in order to get the uniqueness of face features' distances. The more number of images that must be extracted to get the distances between face features have shown the possibility in getting a list of unique face features' distances.

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