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Orientation Angle-based 2D Ear Recognition System

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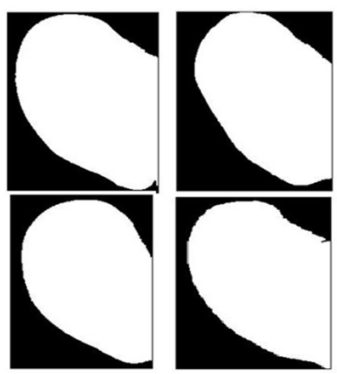
Graphical abstract



Abstract

Ear recognition system has recently become a focus in the biometric field, owning to the rich and stable geometrical structure of the ear. This work proposes the use of orientation angle of the geometrical structure of ear outer edge image for human recognition, since using the pixel value could be erroneous due to pixel intensity variations. After necessary image normalization processes, the edge image of the ear and its coordinates are stored. Subsequently, the feature vector which is the orientation angle of the stored edge image is used in our previously proposed classifier and euclidean distance measure. The proposed method is evaluated using the University of Science and Technology Beijing (USTB) ear database, which confirms to some extent the effectiveness of the proposed technique.

Keywords: Ear recognition; geometric structure; orientation angle; image normalization

■1.0 INTRODUCTION

It is obvious that biometrics is no more a news to the world at large, since the outburst of the information age, that is why [1] said the computer can see now. The fingerprint and iris both after reaching some level of accuracy for recognition, researchers have dived into exploring the ear characteristic trait for human recognition. Ear image is more detailed and strategically located presenting more extractable feature vectors that can be used for authentication. Orientation field has been used widely in fingerprint recognition field domain [2] where researchers have all either used it for classification or recognition purposes [3-5]. A much closer look at this works spurs our quest to establish a fact that this field can equally be applied in ear recognition system. Since the ear structure have a unique orientation and is not likely to be affected by emotion, colour, age at adulthood and mostly presents a smaller spatial space for computation [3] providing room to explore its credibility as a biometric trait. Most of the previous work attempted using different approach like Full Speed Linear Discriminant Analysis, Force Field Transform, SIFT, and Local Gabor wavelet respectively for recognition [7-10]. But this work proposes using the orientation angle of the outer ear edge image for developing an ear recognition system.

The rest of this paper is organized as follows; section II, describes the image preprocessing activities, and section III highlighted the computation process of the orientation angle while section IV, presented feature extraction method. In Section V, experimental result is discussed, and section VI, finally provided the conclusion of the work.

■2.0 EXPERIMENTAL

2.1 2D Ear Preprocessing

The preprocessing activity implemented in this paper follows three different steps, they includes: Cropping of the image, Enhancement and Axis Rotation. The cropping of the ear image involves a best adjustment size of the image by manual cropping and enhancement of the image follows by obtaining an image with a double value from 0 to 1 using the formula

$$\text{Nimg} = \frac{\text{r}*\text{I}-\text{Mn}}{\text{Lrag}+\text{Minds}} \quad (1)$$

Where I is the image.

$$r = Maxd - Minds \quad (2)$$

r being the difference between the standard range value, given as 0 to 1 in this case

$$Lrag = Max - Min \quad (3)$$

Where Min is the minimum value of the image pixel and
Max is the maximum value of image pixel

Then, the image is finally rotated by detecting the landmark of the ear by searching from left top of binarised image shown in Figure 1, to the bottom right and locating the first and last pixels that are one in each case and subsequently rotating the image against a particular angle calculated by formula (4-5).

$$TangentAngle = atan\left(\frac{x}{y}\right) * 180/PI \quad (4)$$

$$RotatedAngle = TangenAngle - 90 \quad (5)$$

The Figure 2 depicts the normalized image which is feed to the next stage of the system.

To this end, the trio image cropping, enhancement and rotation is implemented to normalization the image to ensure that some if not the noise due to occlusion and illumination effects on the image is reduced to the nearest minimum

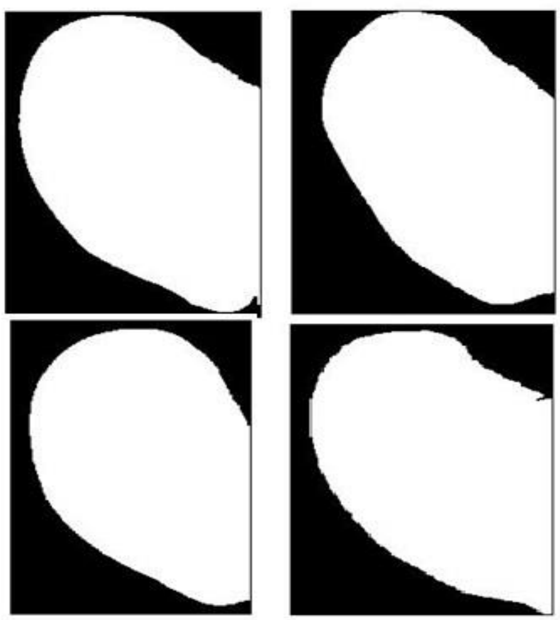


Figure 1 Binary image for axis normalization

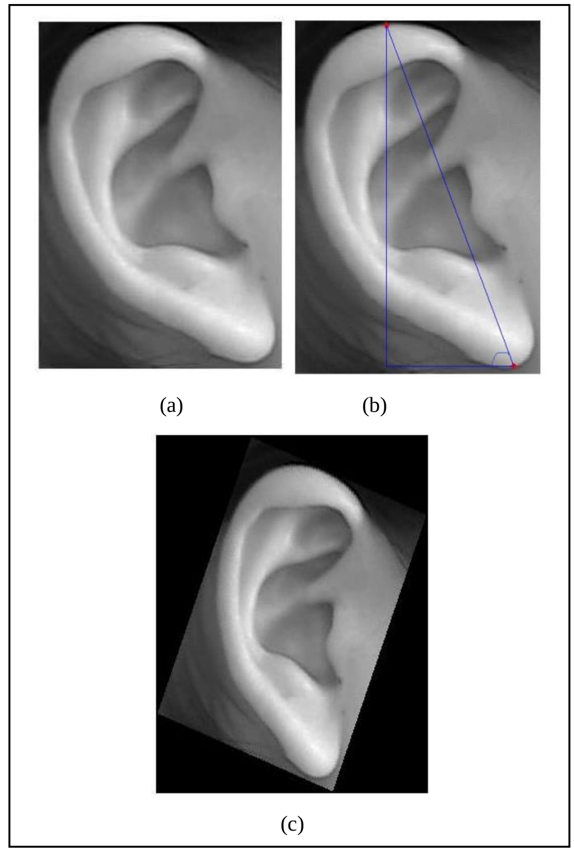


Figure 2 Image preprocessing. (a) Cropped and enhanced image. (b) Localization of Rotational angle. (c) Rotated image with reference to ear landmark

2.2 Computation of Ear Orientation Angle

The preprocessing activities which involve ear image normalization and ear edge detection process of our previous work were applied [1]. After detecting the edge as highlighted above, orientation angle estimation follows.

These depend on the intensity value of the image which has been normalized to be able to reveal the geometrical structure of the ear, which can be used in describing it feature information. The data ear image is smoothened using Gaussian filter and the gradient angle is then computed and Figure 3 shows the output of the orientation image. The following are the steps to estimate the orientation field of the ear image:

i. Given E(A,B) is the ear image information
ii. Given $G_x(A,B)$ and $G_y(A,B)$ are the gradient in the xy-direction.
iii. The covariance $= \frac{\sum_i^n (A_i - \bar{a})(B_i - \bar{b})}{n-1}$ (6)
where $\bar{a}$ and $\bar{b}$ are the means of A and B.
iv. Given the covariance for a, b and ab as G_a, G_b, G_{ab}
v. The

$$deviation = \sqrt{{G_{ab}}^2 + (G_a - G_b)^2} \quad (7)$$

vi. Giving that $G_{vx}(i,j)$ and $G_{vy}(i,j)$ are the x and y element of the vector field, the continuous vector field of the orientation field is computed as

$$G_{vx}(i,j) = \cos(2(\theta_c(i,j)) \qquad (8)$$
$$G_{vy}(i,j) = \sin(2(\theta_c(i,j)) \qquad (9)$$

vii. Compute the orientation field for each block pixel using the formula

$$\theta_f(i,j) = \tan^{-1}\left(\frac{G_{vx}(i,j)}{G_{vy}(i,j)}\right) \qquad (10)$$

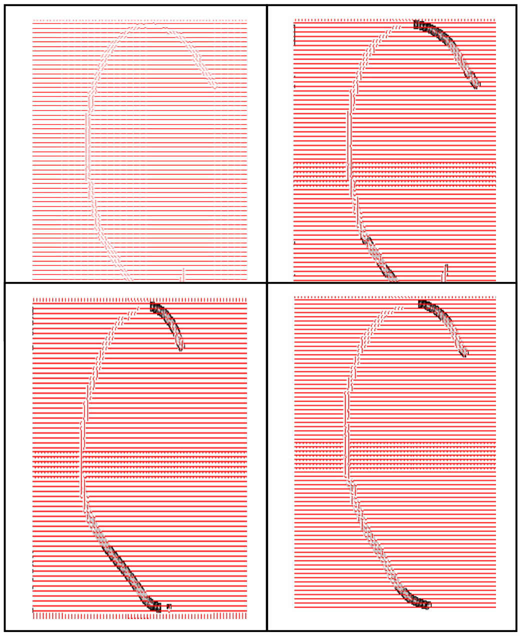


Figure 3 Orientation angle field

2.3 Feature Vector Extraction

The extraction of the pixel orientation angle as a feature vector for this system becomes necessary as computation means reduction of processing time and instead of using image pixel values, the pixel orientation angle values is employed. Having the field as depicted in Figure 3, the extraction of the feature vector values at a notable keypoint becomes necessary. In trying to extract the feature vector for this recognition system, four sets of feature were used. The first and second set of the features were collected from the helix keypoints as showed in Figure 4, while the third made use of the maximum feature vector in the training image which is 478 features. With random selection, the fourth set was obtained as thus

Feature vectors (fv) for the training data:

a) Keep midpoint of the image fv if even and round off the fv point when odd.

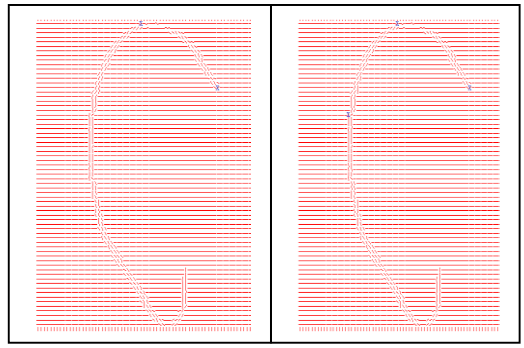
Meanwhile, for the testing data

a) If midpoint fv point value for training = midpoint fv point value for testing or midpoint fv point value for training - fv point value for testing <= 0

Fv point value for testing = midpoint fv point value for testing

Otherwise

b) Midpoint fv point value for testing = midpoint fv point value for testing + next 9 fv point count in testing.



(a) (b)

Figure 4 Feature vector point extraction. (a) 2 feature keypoints (b) 3 feature keypoints

Table 1 Edge image feature vectors

Ear Image	Feature Vectors
1	0.8394 0.8314 0.8338
2	0.8090 0.8312 0.8200
3	0.8265 0.8252 0.8150
4	0.8430 0.8300 0.8151
5	0.8430 0.8618 0.8128
6	0.8421 0.8716 0.8132
7	0.8137 0.8531 0.8141

3.0 RESULTS AND DISCUSSION

In the experimental result, we used USTB ear dataset 2, with 304 images from 77 candidates, each candidate have 4 images captured under illumination and angles. A total of 154 images were used which constitutes 2 images for the 77 candidates, making 77 images for both training and testing respectively. The result constitutes a 4-tier experimental progression, where the four sets of the feature vector were used. Firstly, two keypoints on the helix are located and their feature vector extracted and stored for training and testing data. Secondly, one additional keypoint were included to the two above making the second set having three feature vectors from each image. Table 1 shows the three different vectors extracted from the three keypoints of the helix. While in the third, the maximum image feature vector becomes the number of the features in this case 478 and finally, the fourth extracted the features as explain in the random selection process above. Validating the proposed method our previously designed classifier and euclidean distance similarity measure were employed. It is observed that the result gets improved as the number of feature vectors increases from the first to the second and third, also improved exponentially with the fourth by the aid of our classification system in [1] to 80% recognition accuracy. This is because the search space was drastically reduced by classification making the recognition accuracy to improve. Most of the failed images were as a result of illumination, occlusion due to hair and earrings, but most likely the feature selection approach of the orientation angle of the ear edge image.

■4.0 CONCLUSION

In this paper, ear recognition has been proposed using orientation field of the image pixel instead of the pixels itself. The image is cropped on a best adjustment before it was enhanced using a range value of the image pixels as discussed earlier, to normalize it with respect to intensity variation. Orthogonally, the image was rotated to x-axis and before the orientation field estimation is computed. Extracting the orientation field of the image in four different ways, the random selection technique discussed above with our previously designed classifier shows that our proposed method can be used for recognition system if more computational analysis is performed. The numerical analysis of the orientation field is ongoing which is believed to improve the accuracy of the result.

Acknowledgement

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