Extraction of Unique Feature Sets (Bio-metric Identifier) For Human Ear’s Image using DWT Analysis

Gagandeep Bhatia
(IT Department, GGSIPU, New Delhi, INDIA, gagandeep.kaur.b@gmail.com)

ABSTRACT
The presented paper presents the statistical analysis of the dwt coefficients of ear’s images in order to ascertaining the bio-metrics identity of a person. The dwt coefficients matrix contains the frequency variations of ear’s images in three parts; the lower half of the matrix that contains the low frequency elements that make up the flashy part of the ear, the upper half that contain the high frequency elements in form of noise and diagonal elements that contain the maximum information about the features of the ear’s image. The diagonal elements or dwt coefficients are then analyzed statistically in terms of standard deviation, entropy and covariance to identify the given ear’s image.

Keywords: DWT → Discrete Wavelets Transform, EDT → Euclidean Distance Transform, CCD → Charge Coupled Device, Entropy, SD → Standard deviation

I. INTRODUCTION
Biometrics is the method which is used to identify and verify the identity of a person. Different ways are used nowadays to verify the identity of someone. The biometric which is ideal must be unique, permanent, universal and collectable. But, however, in real life applications, the system with characteristics that satisfies all these requirements is not suitable. Several other viewpoints must be taken into consideration before the implementation starts. Ear based identification is a new and unique method among bio-metrics techniques. If we compare ear with the face or other part, then it is obvious that ears can be used more easily and reliably because shape of the ear cannot be changed with age and time, it is unique, stable and non-invasive.

There are many human identities like face, iris, finger prints, hand gesture and voice etc. In the recent years, ear recognition has been identified as one of the important human bio-metrics in the identity set of humans on account of its invariance due to mood, emotions, health, environment, clothing and most importantly aging.

In the domain of ID determining, the structure of human ear has been widely using and accepted as one of the important human identifier. There are several features by which the human ear can be categorized and can be taken as a confirmatory ID proof like contour, size, shape and geometrical feature. Any CCD or digital camera can be used to take good quality image for human ears and that can be processed to extract the features set for the same. The feature set may include size, width, height, contour and earlobe. Normalization of feature parameters are made to a range so that if the ear image is taken from a distance or near, the parameters should not vary that is parameters are size independent. A rotation independent algorithm is also applied so that if the camera is rotated at some angle, the parameters should not vary that is rotation invariance has to be taken care of.

Feature extraction consists of image analysis and measuring the binary contour characteristics. The features are those parameters that can be obtained on the basis of discrete geometry computations. To quickly identify an object, Classification is used on the basis of its image features. Also, image acquiring of ear is quite easy and does not always need the person’s attention. Therefore ear biometric is suitable of surveillance, security, access control and monitoring applications.

The aim of making and to present this paper is to compare input ear image which is the test image, represented as a feature vector with the database image or the library models and to compute the statistics and analyzed statistically taking mean deviation, standard deviation and covariance to identify the given ear’s image.

II. BRIEF LITERATURE SURVEY
Rajesh and Jayesh presents the paper in which the ear’s bio-metric information [1] or feature datasets are obtained by calculating mean, standard deviation, energy and entropy of six sub-bands of DT-CWT and three sub-bands of DWT Canberra distance and Euclidian distance. 97% recognition rate was achieved using Canberra distance.

Recently, within the last two years, various methods approaches [2] towards multimodal 2D+3D ear biometrics have been developed and published. Sana et al. introduced a new approach in this field based on Haar
wavelets. He applied Haar wavelet transformation and wavelet coefficients are computed, after each ear detection step. Hurley, Nixon and Carter [10] has given a method based on energy features of the 2D image. They used force field transformation to find energy lines, channels and wells. Moreno [2] presented an approach based on neural network. Their work was based on macrofeatures extracted by compression networks. 93% accuracy results were obtained by compression network ear identification method. 3D ear recognition based on local shape descriptor and the ICP algorithm was proposed by Chen and Bhanu [8] Results with 100% rates were obtained.

Principal component analysis (PCA) [9] approach have been used by Victor et al. He compared the face based recognition with the ear and suggested that recognition based on face has given the better performance than ear.

To extract ears from 2D images by using edge images and active contours, Kumar et al. worked upon a database consists of 100 subjects with 7 images per subject. For collecting the data, a special device was used which makes sure that the distance to the camera is constant and that the lighting conditions are the same for all images. A detection rate of 94.29% is reported within this setting.

Online personal authentication using ear images are presented by Kumar, Kuldeep and Gupta. Two feature extraction method using Log gabor [3] and SIFT (Scale invariant feature transform) [3] is tested for online authentication system. Relevant information from the ear contours were extracted as for feature extraction. The ear contours are then used for authentication using log gabor and SIFT features. The SIFT feature has given better authentication rates than GAR that is 95%.

Lammi focused on Principal component analysis (PCA) with photos, earmarks and thermograph pictures. The research of using thermograph pictures [7] should be continued to find out the possibilities identifying partially covered ears. for this, PCA was used and the evaluation was done as in FERET approach.

In 1949, Alfred Iannareli [12] has given a pioneer work in identifying people by using an ear. He collected more than ten thousand ear images in his database and manually measured the distances between different parts of the ear but however, his method was very limited and hard because his measurement needed a fixed determined base point which made his method harder to be used in automatic recognition.

Jeges and Mate presented Modal-based approach [6] for ear identification and schemes for both ear localization and feature extraction. This method allow its application in intelligent video surveillance [6] where people can be identified from distance (remotely) and their identity can be tracked using video camera images. For remote identification, edge orientation pattern matching and active contour are used. Two modules, namely Identification target localization and feature extraction implemented for ears. They were able to improve the method further, decreasing the equal error rate (EER) from 7.6% to 5.6% as measured on their test database.

In late 90’s, Mark Burge and Burger has given the use of voronoi diagrams in automating ear biometrics. He introduced the development of passive identification system. That was a new class of biometrics which was ideal for passive identification because the features are robust and can be reliably extracted from a distance. [11].

III. IMAGE ACQUISITION AND PREPROCESSING
The human’s ear’s image is acquired by using the Nikon make digital camera of 14 mega pixels resolutions (model: CoolPix). The acquired image is in jpeg format and is read in matlab using the command imread(). The image is now converted to gray image using rgb2gray() function. The gray image is enhanced using the histogram equalization algorithm. Following figure show the result of image preprocessing operations:

![Original Images](Fig. 1)
![Histogram Equalized Images](Fig. 2)

![Fig. 3](Fig. 3)
![Fig. 4](Fig. 4)

IV. SEGMENTATION
The enhanced image is now exposed to segmentation algorithm in order to localize the ear’s image. This way, an image is obtained with maximum area coverage by the ear morphology.
V. DWT ANALYSIS

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the image into mutually orthogonal set of wavelets.

The low-frequency content is the most important part in the image. It is what gives the image its maximum energy or information. The high-frequency content, on the other hand, imparts flavor or nuance. In wavelet analysis, we often speak of approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. This filtering process looks like as below:

![Filtering Process](image)

The original image passes through two complementary filters and emerges as two signals Approximations (A) and Details (D). Since the analysis process is iterative, in theory it can be continued indefinitely. In reality, the decomposition can proceed only until the individual details consist of a single sample or pixel. The following figures show the structures of 2-D DWT with 3 decomposition levels:

![Structures of 2-D DWT with 3 decomposition levels](image)

After one level of decomposition, there are four frequency bands, namely Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH).

VI. DWT COEFFICIENTS EXTRACTION

2-D DWT coefficients extraction algorithm is applied on the segmented image in order to compute the dwt coefficients. The coefficients are arranged in an array. The test and standard ear’s images are brought under the 2-D coefficients extraction algorithm. Therefore, we get two columns of M no. of dwt coefficients for test and standard ear’s images.

Let say, there are N no. of standard images and the dwt coefficients are extracted and stored as depository in the data base. The dwt coefficients are arranged as follows for analysis purpose.

<table>
<thead>
<tr>
<th>DWT Coefficients</th>
<th>Standard Image</th>
<th>Test Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1^1$</td>
<td>$S_2^1$</td>
<td>$S_3^1$</td>
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<tr>
<td>$S_2^1$</td>
<td>$S_2^2$</td>
<td>$S_3^2$</td>
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<tr>
<td>$S_3^1$</td>
<td>$S_4^1$</td>
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<tr>
<td>$S_M^1$</td>
<td>$S_M^2$</td>
<td>$S_M^3$</td>
</tr>
</tbody>
</table>

The average of the differential dwt coefficients i.e. difference of standard and test image is given by:

$$\bar{\mu}^i = \frac{\sum (S_i - T_i)}{1152}, \quad i = 1, 2, 3 \ldots 1152$$

The standard deviation is given by:

$$\sigma^i = \sqrt{\frac{\sum (\bar{\mu}_i - S_i)^2}{2xM^2}}, \quad i = 1, 2, 3 \ldots 1152$$

With the above computation process, we have now N no. of standard deviations for the given test input image with those of the standard images. From statistical theory, it can be deduced that the minimum standard deviation image from the standard image has the maximum similarity to that of the given input test image.

Further, the entropy, standard deviation and PSNR are computed from the above set of coefficients.
Entropy $E$: The expression of the information entropy of an image is given by:

$$H = - \sum_{i=0}^{L-1} p(i) \ln p(i)$$

Where $L$ denotes the number of gray level, $p(i)$ equals the ratio between the number of pixels whose gray value equals $i$ (0 to $L$ - 1) and the total pixel number contained in an image. The information entropy measures the richness of information in an image. If $p(i)$ is the const for an arbitrary gray level, it can be proved that the entropy will reach its maximum.

PSNR: The PSNR is defined as follows:

$$PSNR = 10 \log_{10} \frac{255^2}{\frac{1}{N \times N} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (f(i,j) - \hat{f}(i,j))^2}$$

where $N \times N$ is the size of the original image and $f(i,j)$ and $\hat{f}(i,j)$ are the gray-level pixel values of the original and reconstructed images, respectively.

With the above computation process, we have now $N$ no. of standard deviations, entropies and PSNRs for the given test input image with those of the standard images. From statistical theory, it can be deduced that the minimum standard deviation, PSNR and entropies image from the standard image has the maximum similarity to that of the given input test image.

VII. RESULTS
The presented approach has been tested on 100 pairs of ears data base images of size 96x96 pixels. Out of 100 pairs, 40 pairs were taken as standard images and a data base of diagonal dwt coefficients was created and stored in a data file. Further, the rest 60 pairs were taken as input test pairs for identification purpose. Thereby, making 40 classes of different persons. The task is now to identify the 60 pairs of unknown image from the 40 pairs of known images. The performance of the algorithm comes out to be 95-98% success. The same exercise may be carried out further for more validation. Followings are the result as obtained when running the program on few images:

VIII. CONCLUSION
A fair estimate about the identity of a person based on ear’s biometrics is achieved by statistical analysis of the diagonal dwt coefficients. However, a minimum standard deviation limit is required in order to reject the unknown person because there is one value that will always be minimum among a set of standard deviations. That limit may be standardized in percentage to remove the ambiguity of absolute value. The presented approach produced good, repeatable and reproducible results when tested on 100 pairs of ear’s data base images.

REFERENCES

Author’s Profile

Mrs. GAGANDEEP BHATIA B.TECH. in Computer Engineering from Kurukshetra University, Haryana in 2006. Persuaing M.TECH. in Information Technology from GGSIPU, New Delhi. Her research interests are focused on biometrics, Pattern Recognition and Computer Networking.