Statistical Analysis of DCT Coefficients for Ascertaining Ear's Biometrics

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Abstract: ***The presented paper presents the statistical analysis of the diagonal dct coefficients of ear's images in order to ascertaining the bio-metrics identity of a person. The dct 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 dct coefficients are then analyzed statistically in terms of mean deviation, standard deviation and covariance to identify the given ear's image.***

Keywords: Discrete Cosine Transform, Euclidean Distance Transform, Charge Coupled Device

1. Introduction

Comparing face and ear identification, it is obvious that although people use faces in everyday life to recognize their acquaintances, one would not normally attempt to identify another person by their ears; in automated identification, however, ears can be used more easily and reliably than faces. It is generally accepted that any given person's ear shape is unique; therefore computer algorithms can identify the differences, as they can recognize and extract the various distinctive features on ear images in order to distinguish different ears, and thus identify different people.

The structure of human ear has been widely accepted as one of the important human identifier in the domain of ID determining. The human ear can be categorized by its contour, size, shape and geometrical feature set as confirmatory ID proof. A good quality image for human ears can be obtained easily with any CCD or digital camera and can be processed to extract the features set for the same. The feature set may include size, width, height, contour and earlobe. The feature parameters are normalized to a range so that if the ear image is taken from a distance or near, the parameters should not vary. i.e. parameters are to size independent. Also a rotation independent algorithm is applied so that if the camera is rotated at some angle, the parameters should not vary. i.e rotation invariance has to be taken care off. This is covered by orthogonal coordinates system.

Feature extraction consists of binary contour image analysis and measuring the contour features. The features are the parameters that can be obtained on the basis of discrete geometry computations. Classification is used to quickly identify object on the basis of its image features. The aim of this stage is to compare input ear image, represented as a feature vector with the library models (archetypical vectors in database).

2. Brief Literature Survey

The future of biometrics surely leads to systems based on image analysis as the data acquisition is very simple and requires only cameras, scanners or sensors [1]. More importantly, such methods could be passive, which means that the subject does not have to take active part in the whole process or, in fact, would not even know that the process of identification takes place.
There are many possible data sources for human identification systems, but the physiological biometrics has many advantages over methods based on human behavior. The most interesting human anatomical parts for passive, physiological biometrics systems based on images acquired from cameras are face and ear [2]. Both of these methods contain large volume of unique features that allow identifying humans.

Human ears have been used as major feature in forensic science for many years (for example in airplane crashes). Ear prints, found on the crime scene, have been used as a proof in over few hundred cases in the Netherlands and the United States [3]. Nowadays, police and forensic specialists use ear prints as a standard proof of identity [4] [5] [6] [7]. An otoscopic (ear based) forensic opinion has a status of scientific evidence and, as such, is admitted by Polish Courts [8]. In most countries ears have to be visible while preparing photographs for passports and other ID documents.

3. Earlier Work

Based on literature survey, it is observed that the ear biometrics suffers from the rotation, location and size invariance. As the ear's image is subjected to zoom in or zoom out, the size varies. And therefore, the feature set varies. Also as if the image is rotated at some angle, the feature set again varies. In order to make the feature set independent of the size and rotation, the feature set is normalized with respect to size and angle of rotation. In the proposed work, all types of invariance have been worked out.

4. Methodology

The presented work is organized in three different sections: (1) Image Acquisition and Preprocessing, (2) Introduction to DCT Coefficients and Extraction and (3) Statistical Analysis of DCT Coefficients.

4.1. Mage 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:

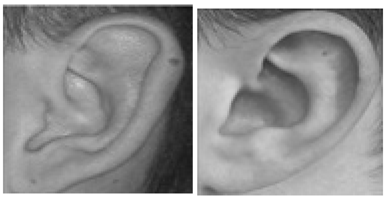

Figure 1: Original Images

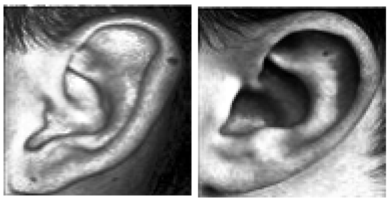

Figure 2: Histogram Equalized Images

5. DCT Coefficients

The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; i.e. the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension. The definition of the two-dimensional DCT for an input image A and output image B is given by:

$$B_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{mn} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p=0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \quad \alpha_q = \begin{cases} 1/\sqrt{N}, & q=0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

where M and N are the row and column size of A, respectively. If the DCT is applied to real data, the result is also real. The DCT tends to concentrate information, making it useful for image compression applications. In the presented work, the enhanced image (obtained by histogram equalization method) is divided into blocks of 8x8 pixels. Therefore, it is required that the image dimensions i.e. row and columns are in multiples of 8. The image size has been standardized to 96x96 pixels in the presented work. For an 8x8 image pixel block, we get an 8x8 dct coefficients matrix. And therefore, in total 8 diagonal dct coefficients. For a 96x96 pixels image, we get 144 blocks of 8x8 pixels, thereby giving 1152 (=144x8) no. of diagonal dct coefficients.

6. Statistical Analysis of DCT Coefficient

The test and standard ear's images are brought under the dct coefficients extraction algorithm. Diagonal dct coefficients of both images are extracted as discussed in earlier section. Therefore, we get two columns of 1152 no. of diagonal dct coefficients for test and standard ear's images.

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

DCT Coefficients				
Standard Image				Test Image
S^1_1	S^2_1	S^3_1...	... S^N_1	T_1
S^1_2	S^2_2	S^3_2...	... S^N_2	T_2
S^1_3	S^2_3	S^3_3...	... S^N_3	T_3
S^1_4	S^2_4	S^3_4...	... S^N_4	T_4
…	…	… …	… …	…
…	…	… …	… …	…
…	…	… …	… …	…
S^1_{1152}	S^2_{1152}	S^3_{1152}	... S^N_{1152}	T_{1152}

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

μ^1 μ^2 μ^3 … μ^N μ^T

where $\mu^i = \Sigma\,(S^i - T^{i)})/1152,$ $i = 1,2,3 \ldots 1152$

The standard deviation is given by:

$\boldsymbol{\sigma^i = \sqrt{\Sigma}\,(\mu^i - S^i)^2/2xM^{2,}}$ $i = 1,2,3 \ldots 1152$

μ^1 μ^2 μ^3 …. μ^N

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.

7. 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 dct coefficients was created and stored in a data file. Further, the rest 60 pairs were taken as input test pairs for identification purpose. There by 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.

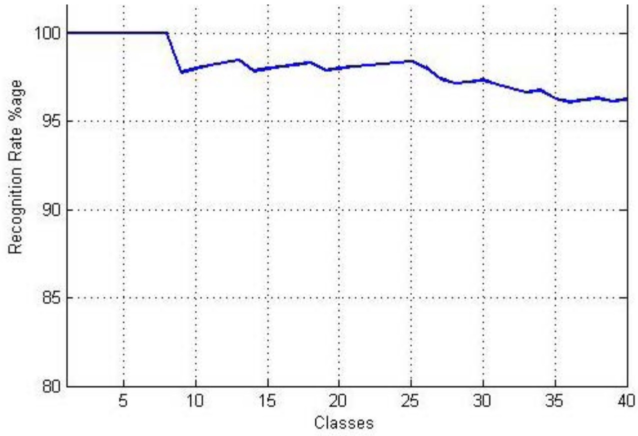

Figure 3: Results of Recognition Rate Vs Classes

8. Conclusion

A fair estimate about the identity of a person based on ear's biometrics is achieved by statistical analysis of the diagonal dct 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 a 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.

9. Future Scope

Ears show a consistent image profile and do not change shape with different expressions or age like faces, and remain fixed in the middle of the side of the head against a predictable background. Further, the ears images are free from variations caused by emotions. The proposed ear-shape analysis could see ear biometrics surpass face recognition as a way of automatically identifying people. The technique could be used to identify people from CCTV footage, or incorporated into cell phones to identify the user.

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