Human Recognition System using Ear biometrics

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Abstract: Automatic person identification becomes essential in surveillance systems. A class of biometrics based on ear detection and recognition is used in a passive identification system. The main goal is to identify a person using ear. We have used Principal Component Analysis (PCA) algorithm which is implemented in MATLAB. The above algorithm is tested on 2-D images and compared with the database of images being created.

Keywords: Ear recognition, Biometrics, Principal Component Analysis (PCA), Ear space, Eigen Ears, Euclidean Distance, Class numbers

1. Introduction

THE science of identifying a human identity based on physical and behavioural characteristics is said as biometric. The human can themselves identify based on their face, body, speech etc. But this task would be much more complex when machines need is used to identify them. Over the years various methods came forward for human identification like passwords, unique ID cards etc. but it has drawbacks like they can share, stolen, forgotten, duplicated, misplaced or taken away. Thus these are not enough reliable methods which should be used in the secure environment.

Later on, methods developed which are universal, distinct, everlasting and collectable based on physical characteristics of the fingerprint, face, iris, ear, speech, hand geometry, heart-beat, DNA etc. [12] Further, they are classified as active and passive. For the surveillance purpose passive biometrics like face, ear etc. where they can be analyzed from a group people precisely and accurately.

The more detailed study has shown that face by itself is not flexible because of due to illumination and expression changes. The same algorithm may give different results due to the ageing of a person.Hence the new system is also used based on ear. The properties of ear such as uniqueness, small size, uniform coloring make it easy for processing. Ear assumed to be constant over 8-70 years thus ear can be used as a biometric tool. In the proposed system, we use PCA method to analyse and finding similarities and differences between the dataset images. The overview of the system is shown in following figure.

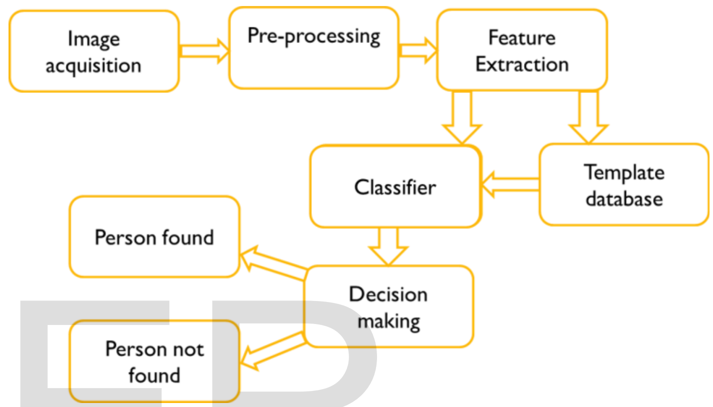

Figure 1: Overview of project

The main purpose in PCA is each original image of the data set can be transformed into a corresponding Eigen ear. This is useful for reducing the dimensionality of the image matrices and hence this is memory efficient. Eigen vector is extracted from the prescribed data set. The Eigen vector thus obtained is compared with template sets in the dataset to establish the match.

2. Related Research

The research for the human ear for identification was started in early 1890 by the French criminologist Alphonse Bertillon [4]. According to him, it is the most significant factor from the point of view of identification.

Later on, Richard Imhofer [3] found that only four different characteristics to distinguish between 500 different ears.

A significant work on is done by Iannarelli [1] in the year 1989 who analysed more than 10,000 ear images and discovered that they can be distinguished by 12 features.

Moreno was the first who describes the automatic system for ear recognition in the year 1999 [2]. For testing purpose, he uses two sets of images. First, include 168 images of 28 subjects having 6 images in one subject and the second was composed of 20 images of 20 individuals. He then represented each feature vector as outer shape and inner structure and

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used a neural network for classification. Victor [5] applied PCA to both face and ear recognition and concluded that the face yields a better performance than the ear. He used 76 images for comparison. But during this process, he does not take into account occlusion due to hair or by earing.

However, Chang et al. [6] conducted a similar experiment based on 197 images training sets and observed that no significant difference was observed between the face and ear biometrics when using PCA. Also, the accuracy obtained was almost 90.9%.

Yan [7] tested various combinations of 2D-PCA, 3D-PCA, and 3D-edges on a dataset of 203 images achieving best results with a fusion of all three.

M. Chorus [8] presented a study on ear biometrics in 2005. Based on 240 image sets using geometric feature extraction techniques he carried our experiments. The geometric features extracted used the points of intersection between circles of different sizes with the calculated centroid as their Centre and the contours extracted from the ear image. This method was carried out on extremely high-quality images and without illumination change. Because the environment was ideal for recognition, the efficiency was very high.

Saleh (2007) [9] used Principal components analysis (PCA) in research for feature extraction and dimensionality reduction. Research also investigated the use of ear images as a supplement to face images in a multimodal biometric system. The base Eigen ear experiment resulted in an 84% rank one recognition rate, and the segmentation method yielded improvements up to 94%.

Mathur (2013) [10] worked on ear recognition by using principal component analysis (PCA) technique. Images after pre-processing were sent through the steps of principal component analysis. The matrix of weight is generated. The weights of the probes were calculated and used along with the original matrix. The results were viewed on a receiver operating characteristic curve thus defining the overall performance of the system under different conditions.

3. Feature Extraction and Classification

The ear has various unique features such as helix, lobe, conchae, etc. We have to use these biometric features as a signature to identify the human being correct. In this project, we have used Principal Component Analysis (PCA) [14] for feature extraction.

3.1 Principal Component Analysis (PCA)

Principal Component Analysis is a powerful and most popular feature extraction technique. PCA is used for reducing dimensionality by avoiding redundant information without much loss. This is one of the most used feature extraction techniques for pattern recognition and compression. PCA uses linear transformations for mapping data from high dimensional space to low dimensional space. In PCA, features of the image are stored in the form of eigenvalues and eigenvectors.

The first step in PCA is converting input image of NxN vector to N2x1 vector whose elements are template pixels i.e. each pixels from image vector is taken row by row and saved as row vector.

$$X = \begin{bmatrix} x_{i1} \\ x_{i2} \\ . \\ . \\ x_{in^2} \end{bmatrix} \tag{1}$$

Then mean of the vector is found by following formula

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{i=n} \begin{bmatrix} x_{i1} \\ x_{i2} \\ . \\ . \\ x_{in^2} \end{bmatrix} \tag{2}$$

Subtract mean value from input image pixels and obtained a new matrix. Let assume "Q".

$$Q = [X_1\text{-}\overline{X}\ X_2\text{-}\overline{X}\ X_3\text{-}\overline{X} \ldots\ldots\ldots Xn\text{-}\overline{X}] \tag{3}$$

Now find covariance matrix "C". C is a square, symmetric matrix and it can be a very large. Let C be the N^2xN^2 matrix.

$$C=QQ^T \tag{4}$$

Eigen vectors are calculated from the covariance matrix.

$$X_j = \overline{X} + \sum_{i=1}^{i=n} g_{ji} e_i \tag{5}$$

Where e_i are the Eigen vectors of C with non-zero eigen values.

The eigen vectors $e_1\ e_2 \ldots e_n$ span an eigenspace.

The scalars g_{ji} are the co-ordinates of Xj in the space also known as k-dimensional point to g.

$$g_{ji} = (X_j - \overline{X})e_i \tag{6}$$

In this way, k-dimensional point of each trained image is formed and stored in the database.

By using same procedure, k-dimensional point of the query image is calculated.

That point is compared with stored database and gives nearest point at output.

Since C is a very large. At a time of implementation, instead of finding C we calculate

$$P= Q^TQ \tag{7}$$

Here, C and P are both symmetric, but C≠PT. Size of C is N^2xN^2 and P is nxn. N is the number of training images, typically n << N.

Let 'e' be the eigenvector of P with eigenvalue of λ.

$Pe= \lambda e$

$Q^TQe= \lambda e$……………….. [Put $P=Q^TQ$]

$QQ^TQe= \lambda Qe$………….... [Multiplied by Q]

C(Qe)= λ(Qe) (8)

Now, Qe is an eigenvector of C with eigenvalue λ.

3.2 Classifier

The last step in the ear recognition is to classify whether query ear image is in our database or not. In this project, we have used a Minimum distance classifier. Here, Euclidean distance of ear image is calculated after projecting eigen ear on ear space. After calculating Euclidean distance, a class who has nearest Euclidean distance is selected.

Detail procedure for classification is given below:

First query image is transformed into the ear space by using following formula.

$$\Omega_c = (eigenvector)^T Q \tag{9}$$

Ear space is given as follows:

$$\Omega = [\Omega_1 \Omega_2 \ldots \Omega_c] \tag{10}$$

Now threshold is decided for comparison of query image with ear space. This threshold is updated automatically as input images added to the database. If there is only one image in the database then eigenvalues of that images are considered as a threshold, and more images are added to the database then average weight of these images are taken as the threshold.

At a time of recognition, the input image is projected onto the ear space, and examines the difference between the projected ear and X. we have already discussed image projection and ear space in PCA section. The Euclidean distance determines the difference between the ear image and ear space.

$$\varepsilon^2 = \|\omega - \omega_n\|^2 \tag{11}$$

In this way, we get class number which has nearest Euclidean distance with query image and person is recognized successfully.

4. Result

We have created a database of 15 people that consist of 5 images of each ear using a digital camera with sufficient light. Images are taken with different angles to increase efficiency. Then images are pre-processed and stored in the database in the form of the eigenvector. We execute our project and calculated the Euclidean distance for the right ear of each person. In the recognition process, we get accuracy around 73.33%.

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The nearest class is number
      1

with a distance equal to
    6.0833e+04

The distance from Ear Space is
    1.5374e+04
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Figure 2: Output window

Class	Person	Minimum Euclidian Distance
1	Capture 1	1.20E+04
	Capture 2	1.27E+04
2	Capture 1	1.00E+04
	Capture 2	1.28E+04
3	Capture 1	7.16E+03
	Capture 2	7.41E+03
4	Capture 1	9.91E+03
	Capture 2	8.77E+03
5	Capture 1	1.19E+04
	Capture 2	1.01E+04
6	Capture 1	9.11E+03
	Capture 2	9.72E+03
7	Capture 1	9.87E+03
	Capture 2	9.53E+03
8	Capture 1	7.04E+03
	Capture 2	8.17E+03
9	Capture 1	8.41E+03
	Capture 2	8.22E+03
10	Capture 1	9.74E+03
	Capture 2	9.51E+03
11	Capture 1	8.60E+03
	Capture 2	8.00E+03
12	Capture 1	7.19E+03
	Capture 2	7.64E+03
13	Capture 1	1.06E+04
	Capture 2	1.01E+04
14	Capture 1	6.70E+03
	Capture 2	6.95E+03
15	Capture 1	8.03E+03
	Capture 2	8.79E+03

Table 1: Euclidean distance of ear images

5. Conclusion

In recent days, ear biometric system becomes emerging and high potential technology. The human ear has universal and unique features which help it to consider as useful biometric. In this paper, we have implemented ear recognition system using PCA. Ear database contains both ear images of 15 individuals. If we increase no. of ear images for each class then accuracy rate can be increased up to 90%. PCA provides less dimensionality by eliminating redundancy and hence memory efficient. In today's fast growing need of security, ear biometrics seems to be a good solution. It can support to other biometric system and emerge as a strong multimodal biometric system.

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