Ear Recognition Using Wavelets

M. Ali¹, M. Y. Javed¹ and A. Basit¹,²

¹Department of Computer Engineering, College of Electrical and Mechanical Engineering, National University of Sciences and Technology, Peshawar Road, Rawalpindi, 46000, Pakistan
²Permanent address: Senior Scientist, TPPD, PINSTECH, P O Nilore, Islamabad, Pakistan

Email: alimansab@hotmail.com, myjaved@cem.edu.pk and abdulbasit1975@gmail.com

Abstract

Ear is a new comer in biometric recognition techniques. Various methods have been employed for ear recognition to improve the performance and making the results comparable with other existing methods. In continuation to these efforts, a new ear recognition method is proposed. Ear images are cropped manually from the side head images. After that wavelet transform is used for feature extraction and matching is carried out using Euclidean distance. Results achieved by using the proposed method are up to 94.3%.

Keywords: Ear recognition, wavelet transform, biometrics

1 Introduction

Biometrics is the science in which an entity is distinguished on the basis of physiological features or behavioural characteristics [1]. Physiological characteristics include fingerprint, iris scan, retina scan, face, thermograms of face, palm print, ear etc. whereas behavioural characteristics consist of gait recognition, odour, voice recognition and signature verification. The results are obtained in biometrics by using single or multiple means. The achieved results indicate that biometric techniques are much more precise and accurate than the traditional techniques. Other than precision, there have always been certain problems which remain associated with the existing traditional techniques. As an example consider possession and knowledge. Both can be shared, stolen, forgotten, duplicated, misplaced or taken away. However the danger is minimized in case of biometric means [2].

The role of biometrics is amenable in all types of security systems. With the threats/advances of technologies, there is always need to search new means for using as stand-alone applications or in conjunction with the existing systems. In order to include any new class of biometric, the condition required is that it should be universal, distinct, everlasting and collectable i.e. all individuals must have those features (universal) and these features should be identifiable for each individual (distinct). The features should not vary (everlasting) and it must be easy to get required information from these features (collectable) [3]. It is obvious that ears are a prominent feature of all persons making it universally acceptable. Ear biometrics has several advantages over complete face: reduced spatial resolution, a more uniform distribution of colours and less variability with expressions and orientation of the face.

In the present paper, a new ear recognition approach using wavelets is applied for human identification. The remainder of the paper is organized as follows. In section 2 background and related work with respect to ear recognition is given. Section 3 includes preprocessing followed by feature extraction and matching in section 4. In section 5 experimental results and discussion are reported and in final section 6 conclusions are made.

2 Background and related work

Ear was first used for recognition of human being by Iannarelli [4] who used manual techniques to identify ear images. Samples of over 10,000 ears were studied to prove the distinctiveness of ears. Structure of ear does not change radically over time. The medical literature [4] provides information that ear growth is proportional after first four months of birth and changes are not noticeable in the age 8 to 70. Victor et al. [5] and Chang et al. [6] used eigen ear for identification. The results obtained were different in both cases. Chang’s results show no difference in ear and face performance while Victor’s results show that ear performance is worse than face. According to Chang views, the difference in result might be due to usage of different image quality. Moreno et al. [2] used 2D intensity images of ears with three neural net approaches (Borda, Bayesian, Weighted Bayesian combination) for recognition. In his work, 6 images from 28 people were used to evaluate the recognition
rate of about 93%. Chen et al. [7] studied two steps iterative closest point algorithm on 30 people with their 3D ear images that were manually extracted. The results reveal 2 incorrect matching out of 60 images.

The methodology adopted for ear recognition in this paper is explained by Figure 1. Main blocks are preprocessing, feature extraction, training and matching. The details are given in the coming sections.

![Figure 1: Steps of the proposed method](image)

### 3 Preprocessing

Images with ear rings, other artifacts and occluded with hairs have not been processed in this research work. Each image is gone through the following steps before feature extraction.

- Ear image is cropped manually from the complete head image of a person.
- Cropped ear image is resized.
- Coloured image is converted to grayscale image.

Manual cropping has been done in the work because automated ear cropping is under process. The sizes of cropped ear image are different. In order to find same number of features from each ear image, resizing the images to unique fixed size of 64*64 pixels is made. Each image was converted from RGB to grayscale (if not in grayscale). Then it was sent to feature extraction module. Figure 2 demonstrates the output at the end of preprocessing step. Figure 2(a) shows the actual image in the database and cropped image is visible in Figure 2(b). Figure 2 (c) and Figure 2 (d) are the resized cropped images with RGB and grayscale respectively.

![Figure 2: (a) Original image, (b) Cropped ear image (c) Resized image and (d) Gray scale image](image)

### 4 Feature Extraction and Matching

After normalizing the ear images, next step is feature extraction. A new technique is implemented for feature extraction using Haar wavelet transform [9]. Haar wavelet of level two is applied to the image and approximation coefficients of second level are stored in a row vector. This vector is of size 256 bytes, which is the desired feature of the processed ear image.

These feature vectors are used for training the database. In training process, the numbers of training images are taken and then feature vector of each image is stored in the training database along with the average of the number of training images. For matching, feature vector of test image is calculated.
Euclidean distance for all the trained feature vectors in the database and the test image is acquired. The image corresponding to the minimum value of Euclidean distance matches with the image under consideration.

![Figure 3: Recognition rate](image)

**5 Experimental Results and Discussion**

The proposed method is implemented in MATLAB 7.0 on a PC with 1.6 GHz Intel processor and 256 MB RAM. In experiments, images from the University of Notre Dame Ear database [8] are used. Database contains a total of 464 images with 1200*1600 pixels resolution containing 114 subjects with ear side view at Yaw of -90 and -75.

A set of 32 people has been used for experiments having six or more images each. Figure 3 shows the results of number of training versus correct recognition rate. It is clear from the figure that as the number of training images is increased, it increases the recognition rate. For two training images, the correct recognition rate achieved is 78.5% and if system is trained on three images, then the accuracy is 84.2%.

Similarly, when number of training images is four, the correct recognition rate is 90.2% whereas it goes up to 94.3% if number of training images is five. Times elapsed for training of three images from the set is 3.8 seconds, whereas it increased to 4.8 seconds and 6.1 seconds for training the dataset with four and five images respectively. The training time for complete set of 32 people varies from 2.8 to 6.1 seconds whereas and recognition time for complete set of images varies from 7.5 to 9.1 seconds respectively as shown in Figure 4.

![Figure 4: Time Analysis](image)

Images used in this experimental work are without rotation. In future work, ear images will be oriented to the same position in preprocessing step. It is expected that this process will enhance the recognition results.

Now the results will be compared with the work done by other researcher in the same field using various techniques. The results obtained using the proposed method are better than Moreno et al. [2]. His results are 93% whereas our method has correct recognition rate 94.3%. Similarly Chen et al. [7] quoted two incorrect matches out of 60 images (i.e. 96.6%). This recognition rate is better because the number of images used in his experiment were very less.

**6 Conclusions**

Ear biometrics got attention to the research community recently. In this paper, a new method of human recognition is proposed based on human ear images using wavelet transform. Ear images are cropped manually and resized to a fixed size followed by conversion to grayscale. After that Haar wavelet transform of level two is used to extract the feature from the image. Database is trained and classification is based on Euclidean distance metric. Results obtained are promising and encouraging with correct recognition rate as well as time required. Results will improve if the orientation of the images is done in preprocessing phase.

**7 Acknowledgements**

Authors would like to thank Mr. Saqib Masood for his valuable suggestions. Thanks are also due for Computer Vision and Research Laboratory at the University of Notre Dame for providing public biometric ear Database Collection Set E on request.
References


