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Fingerprint based Automatic Human Gender Identification

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ABSTRACT

Human beings have unique and distinct characteristics which are helpful to distinguish one human being from another and thus acts as form of identification. Biometric allows us to identify individuals based on some anatomical structures of body such as fingerprints, face , hand-geometry ear and iris etc. Addition to this soft biometric traits such as gender, age and eye color, voice, accent etc. soft biometric traits help to support traditional biometrics by adding some extra meaningful information. In this context, gender identification becomes a significant task to improve the biometric systems[2]. Gender identification plays a vital role in many applications like human computer interaction, content based indexing, decision making, searching, surveillance and demographic studies. In this paper, we present multi-resolution features based method for gender identification using fingerprints. Our method involves three main steps preprocessing, feature extraction and classification. To do preprocessing we employed contrast limited adaptive histogram equalization, discrete wavelet transform for multi-resolution based feature extraction and classification using feed forward back propagation neural network. In our experiments, we have achieved progressive results on dataset of 750 fingerprints.

General Terms

Digital Image Processing, Pattern Recognition

Keywords

Discrete Wavelet Transform, fingerprints, Automatic Gender Identification, Back Propagation Neural Networks

1. INTRODUCTION

Human vision system is self-sufficient and very good in identifying the demographical attributes of human beings such as age, gender, voice, accent etc. For instance, by birth child is able to discriminate between father and mother, without any prior knowledge of gender. At the opposite side, computer vision system is not intelligent to these kind of tasks, therefore automatic gender identification plays significant role for development of several applications for instance, human computer interaction, target advertising content based indexing and retrieval, gait analysis and surveillance etc. Gender identification of person can be done efficiently based on the fingerprints, thanks to ridges of fingerprints which serves as the main feature[4]. It is noted that average ridge density is slightly higher in females than males. fingerprint is considered as basic and easy biometric to identify individuals due to its simplicity and easy availability. The effect of age on fingerprints size and shape can be seen but the pattern of ridges will remain same through out the life. Automatic gender determination also very helpful in forensic investigation where fingerprint serves as main clue.

In this paper, we made an attempt to identify gender from fingerprints using multi-resolution statistical features based discrete wavelet transform (DWT) and feed forward back propagation neural network. The rest of the paper is organized as follows: In section 2 we have briefed the related work. Section 3 deals with proposed method. Experimental analysis is presented in Section 4 and we concluded in Section 5.

2. RELATED WORK

Biometric technology got huge attention in recent past years and enormous development can be seen in research and development of the field. A lot of work is carried out for the fingerprint recognition but limited work is reported for the gender determination. We have briefed some recent algorithms and methods presented in the literature for the gender determination using fingerprints.

Fingerprint based gender identification is reported in [3]. Authors used discrete wavelet transform and singular value decomposition based features with K-Nearest Neighbor Classifier (KNN). In [4], authors extracted global features such as ridge density, ridge thickness to valley ratio(RTVTR) and white lines count, later these global descriptors are fed into multilayer perceptron neural network to classify male and female fingerprints. Use of discrete wavelet transform and principal component analysis is explored in [5], for identification of gender using fingerprints. Haralick texture descriptors based statistical features are extracted from fingerprints in [6] and their performance is evaluated using different classifiers namely K-Nearest Neighbor, Linear Discriminant Analysis and Quadratic Discriminant Analysis. In [7], authors present a method to identify male and female based on fingerprints, to do this authors have performed frequency domain analysis for feature extraction using Fast Fourier Transform (FFT) and Discrete Cosine Transform. They have considered 400 fingerprints of belongs

to the people of different age groups. Based on a calculated threshold value gender of fingerprint is decided. Weakness of the method is that it needs a threshold value which requires a priori knowledge and this algorithm also not involves in scientific mechanism of learning. Authors in [8] reported a scheme based on ridge thickness to valley thickness ratio (RTVTR) with Support Vector Machine (SVM) classifier to classify male-female based on fingerprints. Evaluation of different textures descriptors such as Local Binary Pattern (LBP), Local Ternary Pattern (LTP), Local Phase Quantization and Binarized Statistical Image Features were presented in [9] to estimate gender using fingerprints. In [10] authors reported frequency domain image transformation methods to determine gender based on fingerprints. More detail review is presented in [11].

From our quick review presented in above paragraph, it can be noted that previous studies are carried out on a very limited datasets with conventional tool and techniques, and hence there is need of generalized frame work for gender determination using fingerprints. In this paper, we present an efficient and simple algorithm to identify the gender based on fingerprints which uses multi-resolution statistical descriptors and back propagation neural network classifier.

3. PROPOSED METHOD

Our method involves three steps namely preprocessing, feature extraction and classification. We have applied contrast limited adaptive histogram equalization to enhance the fingerprint image and normalize the intensity values. In the process of feature extraction, we have employed discrete wavelet transform and classification task is done with back propagation neural network. For better understanding, we have shown the schematic representation of prosed method in Fig.1.

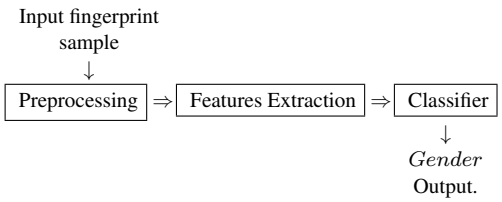

Fig. 1. Schematic diagram of complete work flow.

3.1 Preprocessing

Preprocessing is very significant step and it is application dependent. First we have normalized the input fingerprint image to size $164 * 164$ which is fixed empirically. To normalize the gray values and enhancement of fingerprint image we have applied contrast limited adaptive histogram equalization(CLAHE)[2]. Preprocessing steps are shown in Fig.2.

3.2 Feature Extraction : Discrete Wavelet Transform

Discrete Wavelet Transform is widely used technique for multi-resolution analysis of images from coarse to fine level [12]. We have applied two dimensional discrete wavelet transform to input image of fingerprint which then returns image representation by low-high, high-low and high-high sub bands representing three different details horizontal, vertical and diagonal respectively where

Fig. 2. a) Input fingerprint image, b) Enhanced image after applying CLAHE, c) Image resized to 164*164

approximation of these three is presented in low-low sub band. By applying DWT we have decomposed fingerprint image up to four levels which given us 16 sub bands. Let consider $\psi(a)$ be the mother Wavelet Transform (WT) which is given by :

$$\psi_{(m,n)}(a) = \frac{1}{\sqrt{m}}\psi[\frac{a-m}{n}], \tag{1}$$

where, m and n scale and shifting parameters. By multiplying one dimensional scaling and wavelet function, one dimension wavelets are extended to two dimensional. To get two-dimensional Wavelet transform we have one two-dimensional scaling function $\phi_A(a,b)$ and three two-dimensional Wavelet functions $\psi_H(a,b)$, $\psi_V(a,b)$, $\psi_D(a,b)$. These are the product of one-dimensional scaling ϕ and corresponding Wavelet ψ and these are given as follows

$$\phi_A(a,b) = \phi(a)\phi(b), \tag{2}$$

$$\psi_H(a,b) = \phi(a)\psi(b), \tag{3}$$

$$\psi_V(a,b) = \psi(a)\phi(b), \tag{4}$$

$$\psi_D(a,b) = \psi(a)\psi(b), \tag{5}$$

Where ϕ_A represents global information of an image preserved under low frequency components , which we call approximation coefficients. ψ_H ,ψ_V and ψ_D represents variation along horizontal, vertical and diagonal directions respectively. We have shown two level decomposition of fingerprint image in fig.3.

By applying DWT on each input image, up to four levels of decomposition , we got 16 sub bands. From each sub band we have calculated two statistical measures namely standard deviation(SD) and Entropy (E), due to their efficacy in classification of handwritten and printed text in [13]. We have obtained above mentioned two statistical measures from each sub band and hence we got $16 * 2 = 32$ dimensional feature vector for each input fingerprint image.

3.3 Classification: Back Propagation Neural Network

Neural Network is the biologically inspired classification technique widely used in intelligent information processing. Back propagation algorithm is well known and widely popular method in pattern recognition systems. The back propagation algorithm is used to optimize the performance of the network by adjusting weights with gradient descent algorithm. The big advantage of back propagation algorithm is, it provides highly efficient model free technique for non linear mapping between input and outputs. Back propagation algorithm is explained briefly in below steps :

(1) Input the feature vector to the network.
(2) Propagate feature vector in feed forward way to network layer by layer until it will reach to output.

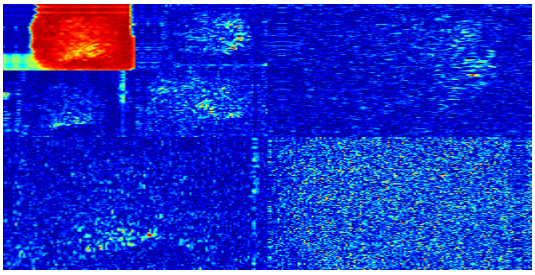

Fig. 3. Two level decomposition of fingerprint image after applying DWT

(3) Compare output network with desired targeted output using loss function and calculation of error value for each neuron.

(4) Back propagate error value starting from output until each error value associated with neurons contribute to original output.

4. EXPERIMENTS

4.1 dataset

Due to unavailability of the standard dataset for gender identification using fingerprints, we have collected our own dataset. To create a dataset we have used fingkey hamster fingerprint capture device. Total 40 males and 40 females belonging to different professions and age group are considered for data collection. From each person 10 fingerprints are collected in two settings without giving them any prior directions. In this way we have got total 800 fingerprints, out of which 740 properly captured fingerprints are considered in this experiment. Samples from our database are shown in Fig.4.

4.2 Evaluation Protocol

To evaluate performance of our method we have used N fold cross validation method. Total dataset is divided in to N equal sub parts, while one sub part serves for testing other N-1 parts are served for training. this procedure is repeated for N times, in such a ways that each sub part serves for training and testing. In our case value of N =10. Average performance is considered as accuracy for proposed method. We have defined the accuracy as given below:

$$Accuracy = \frac{\#\text{Correctly Identified fingerprints in the Class}}{\#\text{ Total fingerprints in the Class}} \times 100 \quad (6)$$

4.3 Results

Our aim is to identify gender using fingerprints, where we trained the system to classify the male and female based on their fingerprint patterns automatically. While considering large dataset of 740 fingerprints patterns belongs to 80 individuals, we have trained back propagation neural network with 1000 epoch and 11 iterations. With the overall accuracy of 96% we achieved encouraging results for gender identification using discrete wavelet transform based multi-0resolution features. We have noted the 97.56% accuracy for male identification and for the the female it is 95.80%. For deeper analysis we have shown the confusion matrix in Table 1. Confusion is occurred due to the low quality images captured during image acquisition process, which are insufficient in information of ridges and their density.

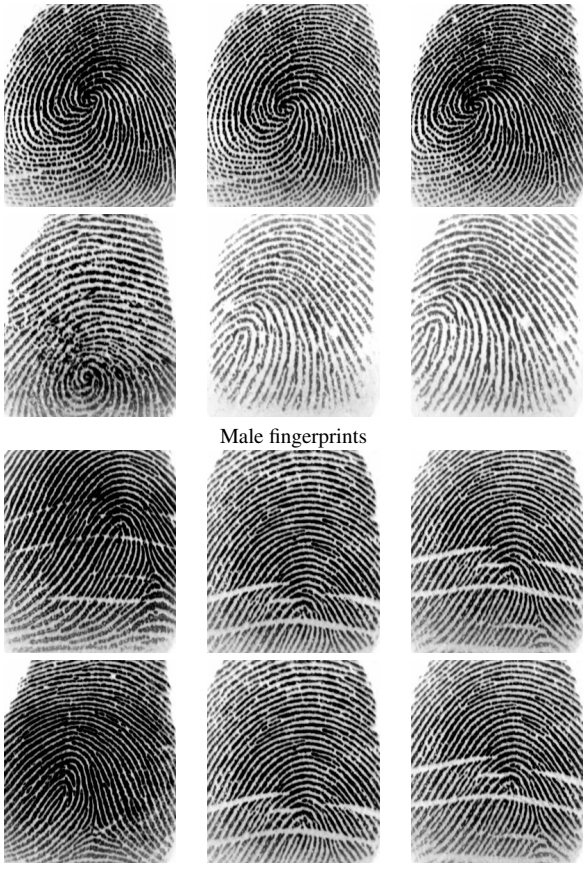

Fig. 4. Sample fingerprints from our dataset.

Table 1.
Confusion Matrix

Male	Female
361	16
9	354

5. CONCLUSION

Gender identification becomes a significant task to improve the biometric systems. It also plays a vital role in many applications like human computer interaction, content based indexing, decision making, searching, surveillance and demographic studies. In this paper we presented a method for gender identification using fingerprints based on multi-resolution statistical features obtained using discrete wavelet transform. Back propagation neural network out performed in gender identification task and has given the accuracy of 96.60%. Further, we also noted that our method is robust against small skew and noise.

Due to unavailability of standard dataset fair comparison with other similar work is not possible. In future, we plan to prepare the bench mark data and experiments for gender identification using fingerprints.

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