



Dermatoglyphics (Age Determination) Wavelet Approach

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Abstract: *Dermatoglyphics means Science of fingerprint. This research implements a novel and simple method of age group classification using fingerprints. Two methods are combined for age determination. The first method is the Singular Value Decomposition (SVD), employed to extract fingerprint characteristics by doing synthesis and reconstruction. The second method is the analysis or feature extraction by using 2D Wavelet decomposition, up to 6 level decomposition used for the process of age identification. This method is experimented with the internal database of 420 fingerprints in different age groups, which contains both male fingerprints and female fingerprints. Tested fingerprint is grouped into following five groups: 6-7, 8-12, 13-15, 16-19, 20-30, 31-50 and above 50. Overall classification rate of 55% has been achieved. Results of this analysis make this method a prime candidate to utilize in forensic anthropology for age classification in order to minimize the suspects search list by getting a likelihood value for the criminal.*

Keywords: *Fingerprints; SVD; Wavelets; BWT; Mode*

I. Introduction

Age of a person can be identified using different biometric traits such as face, iris, retina, speech, gait, hand geometry and fingerprint. Fingerprint is one of the most common traits of human and can be easily obtained. Now a days thumbprints and fingerprint of each finger are taken in order to provide the identity proof to that particular person, e.g. to get a passport or a unique identity card in India, one had to give the impression of his/her thumb and fingerprints. A person's fingerprint is permanent even before they are born. Around 6-8 weeks after conception the volar pads (ball like structures that make up the contour of the fetal hand) form; by 10-12 weeks after conception the volar pads begin to recede; around the 13th week skin ridges appear and take the shape of the receding volar pad; lastly around the 21st week after conception the fingerprint patterns are complete[9].

A Fingerprint is the representation of the epidermis of a finger; it consists of a pattern of interleaved ridges and valleys. Fingertip ridges evolved over the years to allow humans to grasp and grip objects[1,2]. Like everything in the human body, fingerprint ridges form through a combination of genetic and environmental factors. This is the reason why even the fingerprint of identical twins is different [8]. Fingerprint is an impression of friction ridges, from the surface of the finger-tip. Fingerprints have been used for personal identification for many decades; more recently becoming automated due to advancements in the computing capabilities Fingerprints have some important characteristics that make them invaluable evidence in crime scene investigations:

1. A fingerprint is unique to a particular individual, and no two fingerprints possess exactly the same set of characteristics.
2. Fingerprints do not change over the course of person's lifetime (even after superficial injury to the fingers).
3. Fingerprint patterns can be classified, and those classifications then used to narrow the range of suspects [8].

In this work, age identification is mainly based on SVD which is used for synthesis and DWT is used for analysis. DWT is used to obtaining the approximation coefficients. Figure 1 illustrates the DWT and SVD based Age Classification system. function of the Features of fingerprints vary with sexes, ethnic groups and age categories. In this research the fingerprint is obtained from the Digital Persona Optical Fingerprint scanner. This paper is aimed in developing an algorithm for classifying the age through fingerprint.

Wavelet transform is a popular tool in image processing and computer vision because of its complete theoretical framework, the great flexibility for choosing bases and the low computational complexity [5]. As wavelet features has been popularized by the research community for wide range of applications including fingerprint recognition, face recognition and gender identification using face, authors have confirmed the efficiency of the DWT approach [4,5] for the identifications using fingerprint.

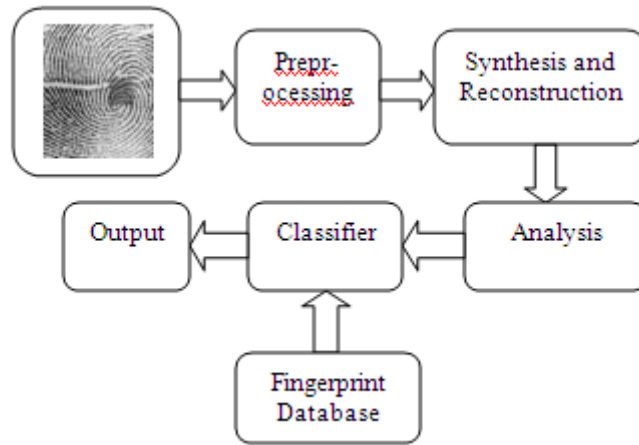


Fig. 1 Block Diagram of Age Determination System.

The SVD approach is selected for the gender discrimination because of its good information packing characteristics and potential strengths in demonstrating results. The SVD method is considered as an information oriented technique since it uses principal components analysis procedures (PCA), a form of factor analysis, to concentrate information before examining the primary analytic issues of interest [5]. Threshold gives very strong consistent results. It uses the database which was generated in the learning stage of the proposed system and it classifies genders of the fingerprints.

II. Proposed Method

A. Preprocessing

I have collected 420 fingerprints (210 males and 210 females) by Digital Persons Optical Fingerprint scanner. Those captured images were stored on .jpg format and in size of 310 X 420 number of pixels. The input fingerprint was enhanced by a series of techniques. Firstly the image was resampled by 300 X 350 no of pixels by using image resizer. Secondly it resized in to 256 X 256 no of pixels. Then the resized image undergoes enhancement technique like histogram equalization. The fingerprint image obtained undergoes image enhancement for improving quality of the ridges and valleys. The output of the preprocessing stage is shown in Figure 2.

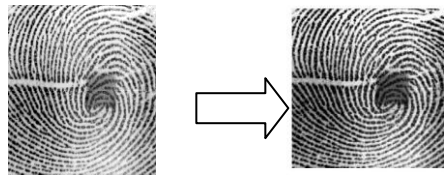


Fig. 2 Input image and Enhanced image

Enhancement techniques used on the fingerprints varies with the quality of the image and types of database used. Poor quality fingerprint image obtained is enhanced for better implementation of algorithm.

B. Singular Value Decomposition(SVD)

The Singular Value Decomposition (SVD) is an algebraic technique for factoring any rectangular matrix into the product of three other matrices. The SVD is the factorization of any real matrix into three matrices, each of which has important properties. Any real $m \times n$ matrix A can be decomposed uniquely as

$$A = U D V^T \quad (1)$$

U is $m \times n$ and column orthogonal (its columns are eigenvectors of AA^T) ie

$$AA^T = U D V^T V D U^T = U D^2 U^T \quad (2)$$

V is $n \times n$ and orthogonal (its columns are eigenvectors of $A^T A$ ie

$$A^T A = V D U^T U D V^T = V D^2 V^T \quad (3)$$

D is $n \times n$ diagonal (non-negative real values called singular values)

$$D = \text{diag}(\sigma_1, \sigma_2, \dots, \sigma_n) \quad (4)$$

ordered so that $\sigma_1 \geq \sigma_2 \geq \dots \geq \sigma_n$ (if σ is a singular value of A , it's square is an eigenvalue of $A^T A$).

If $U = u_1, u_2, \dots, u_n$ and $V = v_1, v_2, \dots, v_n$ then

$$A = \sum_{i=1}^n \sigma_i u_i v_i^T \quad (5)$$

C. Synthesis and Reconstruction

The generation of an image from a mathematical model rather than observation is known as image synthesis. Here image synthesis can be done by using equation

$$P = U * \text{power}(D, 5/4) * V^T \quad (6)$$

The image can be reconstructed by using equation

$$J = \text{enhanced image} + (0.25 * P) / (1 + 0.25) \quad (7)$$

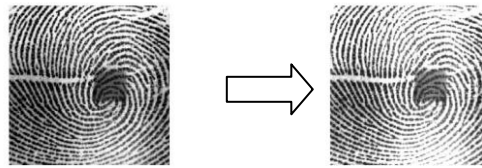


Fig. 3 Enhanced image and Reconstructed image

D. Analysis Using Wavelets

Before knowing wavelet transform let us know about the wavelets. A wavelet is a waveform of effectively limited duration that has an average value of zero. In mathematical term wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale.

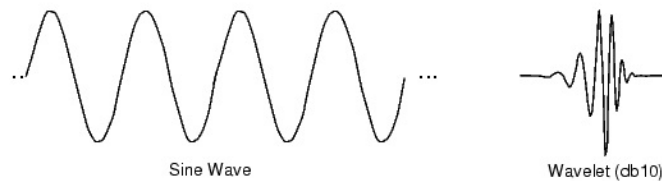


Fig. 4 Comparison of sine wave and wavelet

Fig.4 shows the comparison of wavelets with sine waves. Sinusoids extend from minus to plus infinity i.e. they do not have limited duration. Sinusoids are smooth and predictable whereas wavelets tend to be irregular and asymmetric. Wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet. Fig.4 shows that signals with sharp changes might be better analyzed with an irregular wavelet than with a smooth sinusoid. Many kinds of wavelets exist can be chosen as per the requirement. The principle advantage is that they provide the advantage of knowing existence of a frequency at a particular time interval. Wavelet transform of any function f at frequency a and time b is computed by correlating f with wavelet atom as

$$Wf(a, b) = \int_{-\infty}^{\infty} f(t) \psi(t - \frac{b}{a}) dt \quad (8)$$

Wavelet transform is always defined in terms of a “mother wavelet ψ ” and a scaling function ϕ , along with their dilated and translated versions. The use of wavelet transform on image shows that the transform can analyze singularities easily that are horizontal, vertical or diagonal which can be used in the fingerprint gender classification.

E. Biorthogonal Wavelet Transform

A biorthogonal wavelet is a wavelet where the associated wavelet transform is invertible but not necessarily orthogonal. Designing biorthogonal wavelets allows more degrees of freedom than orthogonal wavelets. One additional degree of freedom is the possibility to construct symmetric wavelet functions.

In the biorthogonal case, there are two scaling functions $\phi, \tilde{\phi}$ which may generate different multiresolution analyses, and accordingly two different wavelet functions $\psi, \tilde{\psi}$. So the numbers M and N of coefficients in the scaling sequences $\tilde{a}$ may differ. The scaling sequences must satisfy the following biorthogonality condition

$$\sum_{n \in \mathbb{Z}} a_n \tilde{a}_{M-1-N} = 2 \cdot \delta_m \quad (9)$$

Then the wavelet sequence can be determined as,

$$b_n = (-1)^n \tilde{a}_{M-1-1N} \quad (10)$$

$$\tilde{b}_n = (-1)^n a_{M-1-N} \quad (11)$$

The scaling equations on the scaling functions and wavelets show that the decomposition and reconstruction of a signal from a resolution to the next one is implemented by perfect reconstruction filter banks.

F. Wavelet Decomposition

The pre-processed image undergoes Biorthogonal Wavelet decomposition in order to obtain vectors in frequency domain. Discrete Wavelet Transformation is a type of transformation in which wavelets are directly sampled. The DWT of a signal x is calculated by passing it through a series of filters. Firstly the sample image was passed through a low pass filter through impulse response g resulting in convolution shown in equation (12)

$$y[n] = x[n] * g[n] = \sum_{k=-\infty}^{\infty} x[k] g[n - k] \quad (12)$$

The signal is also decomposed simultaneously by using a high pass filter h . The two filters used had to be related with each other. This decomposition has halved the time resolution, since only half of each filter output characterizes the signal. Each output has half the frequency band of the input, so the frequency resolution has been doubled. This decomposition is repeated to further increase the frequency resolution and the approximation coefficients decomposed with high and low pass filters and then down-sampled as shown in Figure 5.

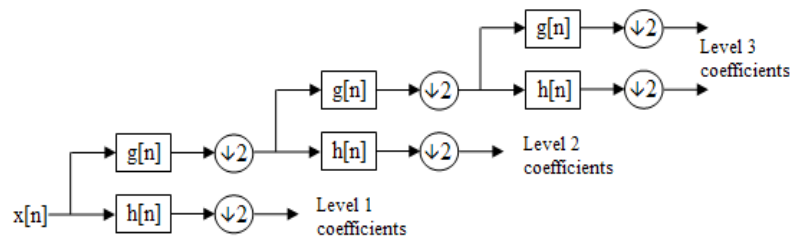


Fig. 5 Level 3 Decomposition

Two dimensional DWT decomposes an image into subbands that are localized in frequency and orientation. The decomposition of images into different frequency ranges permits the isolation of the frequency components as in [1]. The 2-D wavelet decomposition of an image results into four decomposed sub-band images referred to as low-low (LL), low-high (LH), high-low (HL), and high-high (HH) as shown in Fig.6

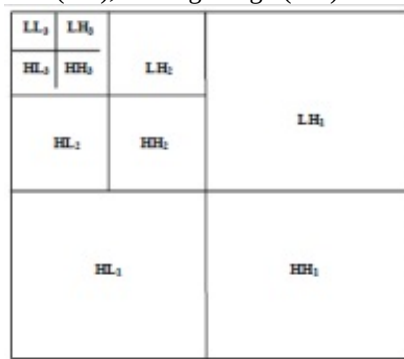


Fig. 6 Subbands after decomposition

Each of these sub-bands represents different image properties. Most of the information's of the images is in the lower frequencies. So the further decomposition of sub band is repeated in LL sub band. For k level DWT, there are $(3*k) + 1$ sub-bands available. Here we using 6 levels of decomposition.

G .Age Classification

Further processing here we using LL sub band only. By an experimental study we choose an image statistical property as a parameter. Here mode is selected as estimated parameter. Mode of each age classification group is different. So that mode for each group can be set by calculating mean of mode under each group. Mean can be calculated in Matlab by using following equation

$$\text{Mean} = \text{sum}(\text{mode})/(\text{number of modes}) \quad (13)$$

III. Results And Discussions

The algorithm of the proposed system is written in MATLAB R2014 and run in Intel Core 2 Duo, 2.20 GHz processor with 2.00 GB memory. Here, we proposed a new and simple method for Age Classification of fingerprints using DWT and SVD. The level 6 DWT is selected as optimum level for the gender classification. Mode of each age classification group is different. Results after each steps were given in previous sections. The success rate is more than 55%. Percentage of result after this study can be obtained is shown in below table.

Table 1.Age Group Classification Accuracy

Sl.No	Age Classification			Over all Accuracy
	Age Groups	Total Fingerprints-60	Accuracy	
1	6,7	32	53%	55%
2	8-12	34	56%	
3	13-15	30	50%	
4	16-19	32	53%	
5	20-30	32	53%	
6.	30-50	30	50%	
7	Above 50	34	56%	

IV. Conclusion

Here we proposed a new and simple method for age group classification from fingerprint images based on Wavelet Transform and SVD technique. This method considered the frequency features of the wavelet domain. The LL block is selected for further processing for the age classification. Mode was chosen as the parameter for gender classification. The proposed system is experimented only on the optical scanned image. Better result will be obtained for digital image. Fingerprint evidence is undoubtedly the most reliable and acceptable evidence till date in the court of law. Due to the immense potential of fingerprints as an effective method of identification an attempt has been made in the present work to analyze their correlation with gender of an individual. The fingerprints of different age groups vary in size and patterns and thickness of ridges and valleys. The fingerprints of people from various ethnic groups vary.

The further improvements hence planned to be done in conjunction with this are blood group determination and heredity checking.

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