AGE CLASSIFICATION FROM FINGERPRINTS –WAVELET APPROACH

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ABSTRACT

This research implements a novel and simple method of age classification using fingerprints. Two methods are combined for gender classification. 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 for feature extraction by using 2D Bi-orthogonal Wavelet decomposition, up to 4 level decomposition used for the process of gender identification. This method is experimented with the internal database of 250 fingerprints finger prints in which 125 were male fingerprints and 125 were female fingerprints. Tested fingerprint is grouped into any one of the following five groups: 6-7, 8-12, 13-15, 16-19, 20-30, 30-50 and above 50. Overall classification rate of 60% 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 gender.

KEYWORDS

Fingerprint, SVD, Wavelets,BWT

1. 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[1].

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 [3].Fingerprint is an impression of friction ridges, from the surface of

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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 .

In this work, age identification is mainly based on image synthesis and analysis. SVD is used for synthesis and BWT is used for analysis. Figure 1 illustrates the BWT and SVD based Age Classification system.

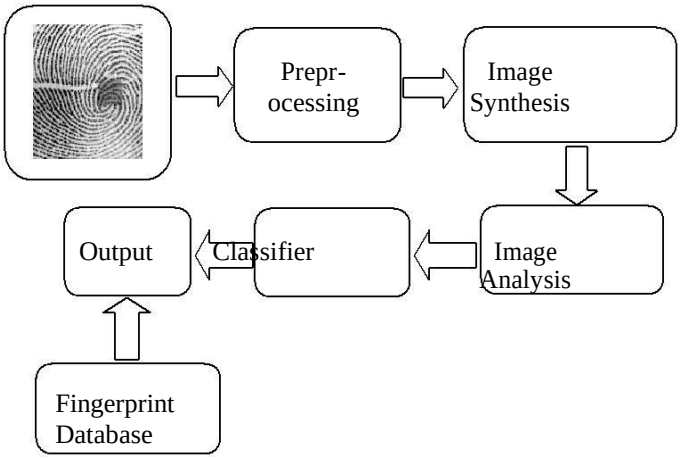

Fig. 1 Block Diagram of Age Classification System.

Features of fingerprints vary with sexes, ethnic groups and age categories. In this case the fingerprint is obtained from the Digital Persona Optical Fingerprint scanner. The paper is aimed in developing an algorithm for classifying the gender 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 [10]. 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 BWT approach [14]for the gender identification using fingerprint.

The SVD approach is selected for the age 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 [13]. 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.

The remainder of this paper is divided into 4 sections. They are as follows: Section II covers the literature review and comparison on the design research of previous systems. We find a lot of the information from Internet. Section III discusses on the proposed method. Section IV describes the performance evaluation of the developed system. Section V concludes the paper and out lines the contributions of the work. The limitations were highlighted and suggestions are made for further development to improve the system.

2. LITERATURE REVIEW

Human fingerprints have been discovered on a large number of archeological artifacts and histological items. Although these findings provide evidence to show that ancient

people were aware of the individuality of fingerprints, it was not until the late sixteenth century that the modern scientific fingerprint technique was first initiated (Jain, et al, 2003). In 1686, Marcello Malpighi, a professor of anatomy at the University of Bologna noted in his writings the presence of ridges, spirals and loops in fingerprints. Afterwards many studies have been conducted on fingerprints based on its patterns and features.

Fingerprint identification and classification has been extensively researched in times past, however very few researchers have studied the fingerprint gender classification problem. Age classification can be made using the spatial parameters or frequency domain parameters or using the combination of both. Most of the findings are based on the spatial domain analysis and few were based on the frequency domain. Earlier work on age classification based on the spatial domain analysis shows that the ridge thickness is different for each age classification groups. [1].

P.Gnanasivam, et al,[4] in 2012 presented a study.In this paper discrete wavelet transform (DWT) and the singular value decomposition (SVD) has been used to estimate a person's age using his/her fingerprint. The most robust

K nearest neighbor (KNN) used as a classifier. The evaluation of the system is carried on using internal database of 3570 fingerprints in which 1980 were male fingerprints and 1590 were female fingerprints. Tested fingerprint is grouped into any one of the following five groups: up to 12, 13-19, 20-25, 26-35 and 36 and above. By the proposed method, fingerprints were classified accurately by 96.67%, 71.75%, 86.26%, 76.39% and 53.14% in five groups respectively for male and by 66.67%, 63.64%, 76.77%, 72.41% and 16.79% for female. Finger-wise and Hand-wise results of age estimation also achieved.

Rijo Jackson Tom, et al, (2013) have proposed a method for Fingerprint Based Gender Classification through frequency domain analysis to estimate gender by analyzing fingerprints using 2D Discrete Wavelet Transforms (DWT) and Principal Component Analysis (PCA).A dataset of 400 persons of different age and gender is collected as internal database. They have used minimum distance method for classification and achieve overall success rate in age classification of around 60% [9].

Ajitha T.Abraham, Yasim Khan M,(2014) have proposed a method for Age classification from fingerprints through frequency domain analysis to classify gender by analyzing fingerprints using 2D Bi-orthogonal Wavelet Transform. A dataset of 250 persons of different age and gender is collected as internal database. They have used wavelet entropy as a classifier and formulated equation is used as threshold for easy classification and achieve overall success rate in gender classification of around 58%[5].

TABLE 1:COMPARISON

Sl. No	Author/Title	Method	Classification Method	Accuracy
1	P.Gnanasivam, Dr.S Muttan[6]2012	SDA & FDA	KNN Classifier method	70%
2	Rijo Jackson, T.Arulkumaran [11] 2013	FDA(2D DWT and PCA)	Minimum distance method	65%
3	Ajitha T.Abraham,Yasim Khan M[5]	FDA(2D BWT)	Threshold setting	58%

3. PROPOSED METHOD

3.1 PREPROCESSING

The actual size of obtained fingerprint is 310 X 420 no of pixels. We took the only center portion of a fingerprint pattern. So firstly the image was cropped by 300 X 350 no of pixels by using image cropping technique. Secondly it resized in to 256 X 256 no of pixels. Then the resized image undergoes enhancement technique like histogram equalization. Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast.

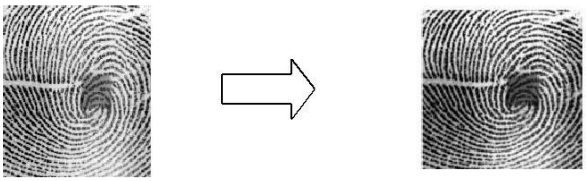

Fig. 2 Input image and Enhanced image

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.

3.2 SINGULAR VALUE DECOMPOSITION(SVD)

Image synthesis is the process of creating new images from some form of image description. For synthesis here we used SVD decomposition. The Singular Value Decomposition (SVD) is an algebraic technique for factoring any rectangular matrix into the product of three other matrices[10]. The SVD is the factorization of any real matrix into three matrices, each of which has important properties. Any real m X n matrix *A* can be decomposed uniquely as

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

U is m X m 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 X n and orthogonal (its columns are eigenvectors of A^TA ie

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

D is m X n diagonal (non-negative real values called singular values)

$$D=diag(\sigma_1,\sigma_2 ,\ldots\ldots,\sigma_n) \quad (4)$$

D is ordered so that $\sigma_1 \geq \sigma_2 \geq \ldots \sigma_n$ (σ is singular value of matrix *A*).

The rank of matrix *A* is equal to the number of its nonzero singular values. In many applications, In many applications, the singular values of a matrix decrease quickly with increasing rank. This property allows us to reduce the noise or compress the matrix data by eliminating the small singular values or the higher ranks.

3.3. SYNTHESIS AND RECONSTRUCTION

The generation of an image from a mathematical model rather than observation is known as image synthesis. For makes use of singular value decomposition (SVD) perturbation, which at first, applies the SVD decomposition on input image (I).

$$[U D V]=svd(I) \quad (5)$$

Here U and V are left and right odd vectors respectively, D is the diagonal matrix of particular values. SVD perturbation [13]uses these singular values to make the derived image (J).

$$J=U * D^i * V \quad (6)$$

where *i* varies between 1 and 2. Finally the derived image is combined with the original image.

$$C = \frac{I+(a * J)}{1+a} \quad (7)$$

where *a* is the combination parameter and it varies from 0 to 1.

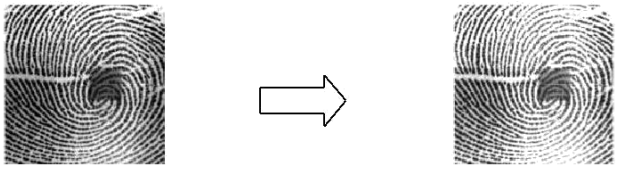

Fig. 3 Enhanced image and Reconstructed image

Individually, this step is not able to perform well under varying conditions. So finally, this paper makes use of wavelet transforms to handle those variations. Wavelet transforms decompose a face image into a number of coefficients that represent an image into different frequency sub bands.

3.4. ANALYSIS USING BI-ORTHOGONAL WAVELET TRANSFORM

Wavelets are developed from the Fourier transform to overcome the drawback of overall domain analysis for which wavelet uses a localized time and frequency analysis. Wavelet plays a vital role in image compression in the part of improving the signal strength. Hence wavelets are widely used in the field where the degradation is not tolerated. Wavelets can also effectively remove the noise in an image.

Wavelet transform is defined as the infinite set of various transforms. Which uses the function that are localized in both the real and Fourier space. Wavelet transform of any function *f* at frequency *a* and time *b* is computed by correlating *f* with wavelet atom as

$$W(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} f(t)\psi\left(\frac{t-b}{a}\right) dt \qquad (8)$$

Wavelet transform is always defined in terms of a " mother wavelet ψ" and a scaling function φ , along with their dilated and translated versions. Wavelet transform is defined as the infinite set of various transforms. Which uses the function that are localized in both the real and Fourier space.

A bi-orthogonal wavelet is one type of wavelet in which the associated transform is inversing but it is not necessary to be orthogonal. It gives freedom in designing bi-orthogonal wavelets than orthogonal wavelets. Additional freedom is the option to create symmetric wavelet function [10]. It compactly supports symmetric analyzing and synthesis wavelets and scaling functions. There is quite a bit of freedom in designing the bi-orthogonal wavelets, as there are no set steps in the design process [11]. It has a property of linear phase which is needed for image reconstruction. The properties can be derived by using two wavelets – Decomposition and Reconstruction instead of using a single wavelet[11].

Analysis (decomposition) and synthesis (reconstruction) filter orders for Biorthogonal filters Specify the order of the analysis and synthesis filter orders for Biorthogonal filter banks as 1.1, 1.3, 1.5, 2.2, 2.4, 2.6, 2.8, 3.1, 3.3, 3.5, 3.7, 3.9, 4.4, or 5.5, 6.8. [10] Unlike orthogonal wavelets, Biorthogonal wavelets require two different filters one for the analysis and other for synthesis of an input. The first number indicates the order of the synthesis filter while the second number indicates the order of the analysis filter. The default is 1/1. For the perfect reconstruction equation to hold, the scaling and the wavelet coefficients have to fulfil the following equations:

$$\tilde{g}(n)=(-$$
$$g(n)=(-$$

It is clear that when the analysis and the synthesis filters "orthogonality" condition in this case is defined by:

$$h(1-n) \quad (9)$$

$$\tilde{(1-n)} \quad (10)$$

are similar, the system becomes orthogonal. The

$$\sum_n \tilde{h}(n)h(n+2k)=\delta(k) \quad (11)$$

Depending upon the various performance factor, the efficiency of various wavelets is analyzed and it is instituted that bior4.4 has the greatest efficiency in compressing the fingerprint image.

3.5. SUBBAND DECOMPOSITION

There are two approaches to the subband decomposition of two – dimensional signals using two – dimensional filters, or using separable transforms that can be implemented using one – dimensional filters on the row first and then on the columns. Most approaches, use the second approach. Figure 6 shows how an image can be decomposed using subband decomposition. Of the four sub images, the one obtained by low – pass filtering the rows and columns is referred to as the LL image; the one obtained by low – pass filtering the rows and high – pass filtering the columns is referred to as the LH image; the one obtained by high – pass filtering the rows and low – pass filtering the columns is called the HL image; and the subimage obtained by high – pass filtering the rows and columns is referred to as the HH image [11]. Figure 4 demonstrate the subband decomposition of an NxM image.

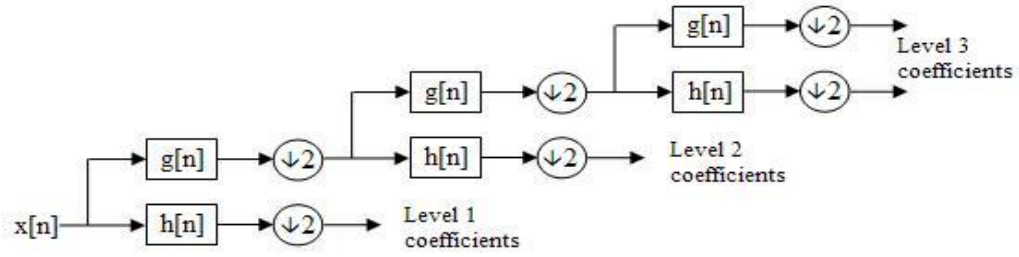

Fig.4 Subband decomposition of an N × M image

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 4 levels of decomposition[11].

3.6 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. The mode is the value that occurs most often. If no number is repeated, then there is no mode for the list. Mode is the most suitable statistical property used for age determination. Mode of the

2D matrices can be calculated by using following steps.

[1] Convert the given matrix to a column matrix.
[2] Calculate the minimum and maximum number of column matrix.
[3] Counting the number of times, each number is present between minimum and maximum number.
[4] Calculate which number is occurs most often.
[5] Mode = most occurred number + minimum of column matrix – 1.

By an experimental study we concluded that in each group of age classification most often number is different. By applying this method ,we can classified 7 different groups such as 6-7,8-12,13-15,16-19,20-30,31-50 and above 50.

4. 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 BWT and SVD. In this section, the performance of the proposed Age estimation algorithm is verified by using the internal database. The success rate (in percentage) of age classification using the combination of both BWT and SVD are summarized and discussed. BWT level 5, 6, 7 and 8 were tried and from the results, BWT level 4 is identified as the optimum for the age estimation.

Mode of each age groups is different. Results after each steps were given in previous sections. The success rate is more than 60%. By proposing this new approach overcame all drawbacks of our previous work. 7 group of classification was obtained. Percentage of result after this study can be obtained is shown in below table.

In table 2 the success rates (in percentage) of age estimation for the fingerprints are tabulated. For the fingerprints of the persons whose age lies between 16-19 years, the success rate is achieved with 52%. The success rate in the age group of above 50 is reasonably good (60%) and thus useful for crime investigation, as this group crime rate is higher than other groups. Similarly the success rate for the remaining group is achieved as 56% for age groups 6-7 and 20-30, 53% for 8-12 and 13-15 and 55% for the age group of 30-50 respectively. Maximum success rate is achieved in the age group of ‘above 50’ for the left thumb. Low success rate is recognized for the age group of 16-19.

TABLE 2. AGE CLASSIFICATION ACCURACY

	Age Classification			
Sl. No	***Age Groups***	***Total fingerprints-60***	***Accuracy***	***Over all Accuracy***
1	6,7	34	56%	60%
2	8-12	32	53%	
3	13-15	32	53%	
4	16-19	31	52%	
5	20-30	34	56%	
6	30-50	33	55%	
7	Above 50	36	60%	

Age group-wise average success rate for fingerprints is shown in the line diagram of figure 6. Maximum success rate of 60% is achieved for the age group of ‘above 50’ years. For the age

group of ’16-19’, the success rate is low(52%).

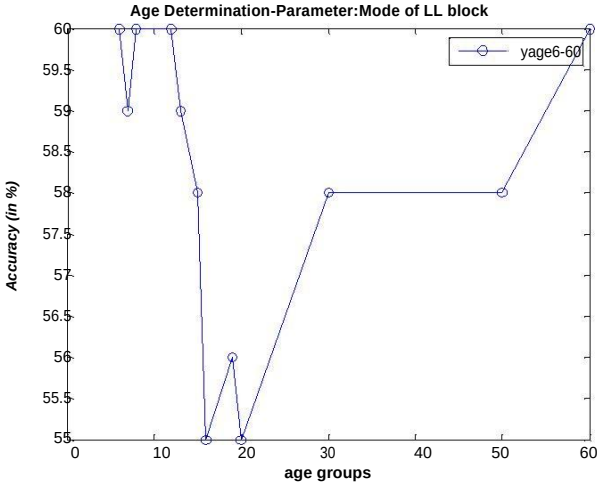

Fig.5 Age group-wise Average success rate

5. CONCLUSION

Here we proposed a new and simple method for age 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 choose as the parameter for age classification.

The proposed system is experimented only on the optical scanned image. Better result will be obtained for digital image. It was found that increasing the database population in each category improves the performance of the system. The further improvements hence planned to be done in conjunction with this are age determination, blood group determination and heredity checking.

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BIOGRAPHY

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