Dermatoglyphics-Wavelet Approach

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Abstract- Dermatoglyphics means science of fingerprint. The main goal of this paper is developing and introducing a new and simple technique for Gender and Age classification. Proposed method is completely done in Frequency domain. Classification is achieved by feature extraction based on Biorthogonal Wavelet Transform (BWT). Energy and Entropy are selected as two features which used for classification .This method is experimented with internal database of 400 fingerprints in different age groups. The experimental results show that the algorithm supplies solutions very close in frequency domain and provide more accurate results.

Keywords – Gender and Age classification, BWT, Energy, Entropy

I. INTRODUCTION

A fingerprint in its narrow sense is an impression left by the friction ridges of a human finger[1]. Each person has his own fingerprints with the permanent uniqueness. So fingerprints have been used for identification and forensic investigation for a long time. Sex and Age identification of suspect from crime scene is an important task in forensic science that minimizes the search population of suspects. Existing methods for gender and age classification depend on the availability of teeth, bones, or other identifiable body parts. Fingerprint has been used as a biometric for the gender and age identification because of its unique nature and do not change throughout the life of an individual.

A wavelet is a mathematical function useful in digital signal processing and image processing. The use of wavelets for these purposes is a recent development, although the theory is not new. Wavelet families can be divided into two main categories, orthogonal and Biorthogonal wavelets, which have different properties of basis functions. Orthogonality decorrelates the transform coefficients there by minimizing redundancy. Symmetry provides linear phase and minimize border arti-facts Other Important properties of wavelet functions in image denoising applications are compact support, symmetry, regularity and degree of smoothness [2]. The Biorthogonal wavelet transform is an invertible transform. The property of perfect reconstruction and symmetric wavelet functions exist in biorthogonal wavelets because they have two sets of low pass filters (for reconstruction), and high pass filters (for decomposition). One set is the dual of the other[3].

The rest of the paper is organized as follows. Proposed algorithms are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. PROPOSED ALGORITHM

A. Gender classification algorithm –

We have used 125 male fingerprints and 125 female. The fingerprints of both classes are grouped and kept as the database fingerprints. Steps to be followed for Gender classification are

Step1: Image Acquisition

A fingerprint sensor is an electronic device used to capture a digital image of the fingerprint pattern. The captured image is called a live scan. This live scan is digitally processed to create a biometric template (a collection of extracted features) which is stored in .jpg format in size 310 X 420. During enhancement, “noise” caused by such
things as dirt, cuts, scars, and creases or dry, wet or worn fingerprints is reduced, and the definition of the ridges is enhanced. We collected total 400 fingerprint images by optical fingerprint scanner Digital Persona manufactured by Grey Technologies, Kochin, Kerala.

Step2: Image Resampling

We need the center portion of fingerprints, so the actual size of captured image was reduced by 300X350 size by using online image resizer. Image resampling physically changes the number of pixels in image (the Pixel Dimensions). The Resample Image option at the bottom of the Image Size dialog box controls whether resizing or resampling an image.

Step3: Image Resizing

Image resizing keeps the number of pixels in our image the same and affects only how large our image will print (the Document Size). Resizing images by changing the width, height and/or resolution values in the Document Size section of the Image Size. The resampled image is resized by 256X256 by using matlab functions.

Step4: Image Enhancement

Fingerprint Image enhancement is used to make the image clearer for easy further operations. Since the fingerprint images acquired from scanner or any other media are not assured with perfect quality, those enhancement methods, for increasing the contrast between ridges and valleys and for connecting the false broken points of ridges due to insufficient amount of ink, are very useful for keep a higher accuracy to fingerprint recognition. Originally, the enhancement step was supposed to be done using the canny edge detector. But after trial, it turns out that the result of an edge detector is an image with the borders of the ridges highlighted. Using edge detection would require the use of an extra step to fill out the shapes which would consume more processing time and would increase the complexity of the code.

So, for this part of the project, two Methods are adopted for image enhancement stage: the first one is Fourier Transform; the next one is Histogram Equalization.

1. Fingerprint Enhancement by Fourier Transform

Divide the image into small processing blocks (32 by 32 pixels) and perform the Fourier transform according to:

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) X \exp \left\{ -j2\pi \left( \frac{ux}{M} + \frac{vy}{N} \right) \right\}$$

for $u = 0, 1, 2, ..., 31$ and $v = 0, 1, 2, ..., 31$.

In order to enhance a specific block by its dominant frequencies, we multiply the FFT of the block by its magnitude a set of times. Where the magnitude of the original FFT $= \text{abs} (F(u,v)) = |F(u,v)|$

Get the enhanced block according to

$$g(x,y) = F^{-1} \{ F(u,v)^X |F(u,v)|^k \}$$

where $F^{-1}(F(u,v))$ is done by:

$$f(x,y) = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} F(u,v) X \exp \left\{ j2\pi \left( \frac{ux}{M} + \frac{vy}{N} \right) \right\}$$

for $x = 0, 1, 2, ..., 31$ and $y = 0, 1, 2, ..., 31$.

The $k$ in formula (2) is an experimentally determined constant, which we choose $k=1$ to calculate. While having a higher "k" improves the appearance of the ridges, filling up small holes in ridges, having too high a "k" can result in false joining of ridges.

2. Image enhancement by Histogram equalization

Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptual information. The enhanced image after FFT has the improvements to connect some falsely broken points on ridges and to remove some false connections between ridges. Fingerprint Image enhancement is used to make the image clearer for easy further operations. Since the fingerprint images acquired from scanner or any other media are not assured with perfect quality, those enhancement methods, for increasing the contrast between ridges and valleys and for connecting the false broken points of ridges due to insufficient amount of ink, are very useful for keep a higher accuracy to fingerprint recognition.

Step5: Wavelet Decomposition
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In case of two-dimensional image, after a BWT decomposition, the image is divided into four corners, upper left corner of the original image, lower left corner of the vertical details, upper right corner of the horizontal details, lower right corner of the component of the original image detail (high frequency). Decomposition then continue to the low frequency components of the same upper left corner of the 2nd, 3rd inferior wavelet transform.

![Figure 1. BWT Decomposition model](image)

Each of these sub-bands contains different coefficients. These coefficients represent different image properties. Here I choose 6 level decomposition of image.

**Step 6: Wavelet Energy calculation**

On the basis of such considerations, the algorithm uses different parameters such as wavelet energy and wavelet entropy for gender and age classification respectively. The energy of all the sub-band coefficients is used as feature vectors individually which is called as sub-band energy vector (E_k).

The energy of each sub-band is calculated by using the equation,

$$E_k = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} |X_k(i, j)|$$  \hspace{1cm} (4)

where X_k(i, j) is the pixel value of k^th sub-band and M, N is width and height of the sub-band respectively.

We got percentage of energy corresponding to the approximation (Ea), and vectors Eh, Ev, Ed, which contain the percentages of energy corresponding to the horizontal, vertical, and diagonal details, respectively. So we got 19 subbands and 19 energy feature vectors after the end of the six level decomposition for each fingerprint.

**Step 7: Setting a threshold value**

To set a threshold value we find the sum, average and standard deviation of three details. In this paper we are finding the threshold value for diagonal and horizontal details using the equations

$$Th_d = \frac{m}{q} + 10$$  \hspace{1cm} (5)

$$Th_h = \frac{m \times q + S}{q}$$  \hspace{1cm} (6)

Th_d and Th_h=Threshold energy of Diagonal and Horizontal Energy

where m(average)=sum(x)/n
x=energy in each level
n=number of decomposition levels (here n=6)
S(standard deviation)=sqrt(sum((x-m).^2/n))
q=number of samples in database
S=total sum of horizontal energy

Steps which we followed in both stages are shown in Fig.2
B. Age Classification algorithm –

Figure 2 Gender and Age classification algorithm Block Diagram
This algorithm process is similar to the Gender classification process. After collecting fingerprint samples, some preprocessing work such as resampling, resizing, etc. have been carried out. All collected fingerprints are resized to 256x256. The fingerprint image obtained undergoes fft enhancement and image enhancement for improving the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. Moreover fingerprint images contain noises caused by factors such as dirt, grease, moisture, and poor quality of input devices and are one of the noisiest image types. Therefore, fingerprint enhancement has become a necessary and common step after image acquisition.

After enhancement process the wavelet decomposition is performed on the image to generate the approximate coefficients and detail coefficients. The energy of each subband is calculated by using equation (4). Here we considered the percentage of energy corresponding to the approximation $(E_a)$. With $E_a$ we can easily classified three classifications in age groups such as 6-16, 17-49 and above 50.

We have used 180 fingerprints. The fingerprints of three classes are grouped as in the age groups 6-16, 17-49, and above 50, and kept as the database fingerprints. Steps to be followed for Age classification using are:

1. Input fingerprint whose age has to be classified from the database.
2. The fingerprint resized to 256x256 and undergoes pre processing.
3. The fingerprint undergoes Wavelet Decomposition and the 19 feature vector is obtained.
4. $E_a$ Feature vector is obtained from wavelet decomposition is used as parameter to generate an output.
5. Threshold is set to $Th$. Rule is set in such a way that if the output generated is greater than $Th$ the decision is age belongs to 17-49 and if the output generated is less than $Th$ the decision will be age group belongs to either in 6-16 or above 50. $Th$ can set by using equation

$$Th=\frac{\text{sum}(E_a)}{n}$$

where $E_a=\text{energy corresponding to the approximation}$

$n=\text{number of samples in database}$

The second age group (17-49) can be further classified in to two groups (17-19 and 20-24) using the algorithm given below. Separated algorithms should be used for males and females. For this classification we choose wavelet entropy as a parameter. This is very little study on the accurate definition and mechanism of wavelet analysis based entropy principle, and there is not intact theory frame and system at all[6,7]. The entropy $E$ must be an additive cost function such that $E(0) = 0$

$$E(s) = \sum_i E(s_i)$$

$s$ is the signal and $(s_i)$, the coefficients of $s$ in an orthonormal basis.

Here we used threshold entropy ($p=0.3$) for classification. It is given as

$$E(s_i) = \begin{cases} 1 & \text{if } |s_i| > p \\ 0 & \text{elsewhere} \end{cases}$$

$E_s = \#\{ i \text{ such that } |s_i| > p \}$ is the number of time instants when the signal is greater than a threshold $p$.

1. **Algorithm for female age group (17-19 and 20-24) determination**

   We have used 40 female fingerprints in each group. All these fingerprints are obtained by means of optical scanner. For age classification the database contains only two classes, age group 17-19 and 20-24. Steps to be followed for Female Age classification are:

   1. The fingerprint undergoes resampling by 300x350.
   2. Resampled image undergoes resizing by 256 x 256
   3. fft enhancement
   4. Image enhancement by histogram equalization
   5. Enhanced image is divided in to four blocks
   6. Calculate wavelet entropy for each block
   7. Calculate average and standard deviation of entropies in four blocks.
   8. Setting a threshold value for easy age classification.

2. **Algorithm for male age group (17-19 and 20-24) determination**

   Above algorithm which used for female age classification is not applicable for male age classification in this groups. Here we have used 40 male fingerprints in each group. All these fingerprints are obtained by means of
optical scanner. For this age classification the database contains only two classes, age group 17-19 and 20-24. Steps to be followed for Male Age classification are
1. The fingerprint undergoes resampling by 300x350.
2. Resampled image undergoes resizing by 256 x 256
3. fft enhancement
4. Image enhancement by histogram equalization
5. Enhanced image is divided in to four blocks
6. Calculate wavelet entropy for each block
7. Calculate sum of four entropies.
8. Set a threshold value for easy age classification.

III. EXPERIMENT AND RESULT

This algorithm was written in MATLAB 2014 and was run on Intel Core 2 duo processor 1.66 GHz with 1 GB memory. Results show us that frequency domain analysis of fingerprints can also be followed in future for the study of dermatoglyphics. The proposed scheme is tested using optical scanned fingerprints.

(a) Gender Classification
Results-(1) Horizontal energy (Eh) of females is greater than males
(2) Diagonal energy (Ed) of males is greater than females

\[
\begin{align*}
\text{Eh} & = 0.0166 \quad 0.0709 \quad 0.4282 \quad 0.0689 \quad 0.1398 \quad 0.1802 = 0.9046 \\
\text{Th}_h (\text{Threshold of Horizontal Energy}) & = 0.6000, \text{Eh} > \text{Th}_h \\
\text{Result : female fingerprint}
\end{align*}
\]

\[
\begin{align*}
\text{Ed} & = 0.0014 \quad 0.0029 \quad 0.0446 \quad 0.2429 \quad 0.0103 \quad 0.0168 = 0.3189 \\
\text{Th}_d (\text{Threshold of Diagonal Energy}) & = 0.2300, \text{Ed} > \text{Th}_d \\
\text{Result : male fingerprint}
\end{align*}
\]

(b) Age classification
Result : Ea is greater for age group (17-49) than in age group 6-16 and above 50

Figure 3. (a) female fingerprint (b) male fingerprint: (Right) Shows Results
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\[ Ea = 98.7542 \]
\[ Ea > T_{ea} (\text{Threshold of } Ea) = 95.000 \]
Result: Age in group of 17-49

\[ Ea = 90.9923 \]
\[ Ea < T_{ea} (\text{Threshold of } Ea) = 95.000 \]
Result: Age in group of 6-16 or above 50

Figure 4. (a) fingerprint in age 32 (b) fingerprint in age 60 (Right) Shows Results

(c) Age classification in age group 17-49
Result: (1) In Females- Standard deviation of entropies is greater for age group 17-19 than 20-24
(2) In Males- Sum of entropies is greater for age group 17-19 than 20-24

\[ \text{stdev} = 444.1584 \]
\[ \text{stdev} > T_{stdev} (\text{Threshold of Standard Deviation} = 300.00) \]
Result: Age in group of 17-19

\[ \text{stdev} = 286.3922 \]
\[ \text{stdev} < T_{stdev} (\text{Threshold of Standard Deviation} = 300.00) \]
Result: Age in group of 20-24

Figure 5. (a) female fingerprint in age 19 (b) female fingerprint in age 23 (Right) Shows results
Table 1 shows the percentage performance of our proposed method of Gender classification. Our method is very simple and has a better performance than others.
Table -2 Experiment Result For Age Classification

<table>
<thead>
<tr>
<th>Proposed Method</th>
<th>Male Fingerprint</th>
<th>Female Fingerprint</th>
<th>Percentage of Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-16(total 50 fingerprints, Male-25 &amp; Female-25) (Wavelet Energy Method)</td>
<td>24</td>
<td>24</td>
<td>96%</td>
</tr>
<tr>
<td>17-19(total 100 fingerprints, Male-50 &amp; Female-50) (Wavelet Entropy Method)</td>
<td>30</td>
<td>30</td>
<td>60%</td>
</tr>
<tr>
<td>20-24(total 100 fingerprints, Male-50 &amp; Female-50) (Wavelet Entropy Method)</td>
<td>20</td>
<td>20</td>
<td>60%</td>
</tr>
<tr>
<td>25-49(total 100 fingerprints, Male-50 &amp; Female-50) (Wavelet Energy Method)</td>
<td>48</td>
<td>48</td>
<td>96%</td>
</tr>
<tr>
<td>Above 50 (total 50 fingerprints) (Wavelet Energy Method)</td>
<td>23</td>
<td>23</td>
<td>92%</td>
</tr>
</tbody>
</table>

Table 2 shows the percentage performance of our proposed method of Age classification in different groups. Our method is very simple and has a better performance than others.

IV. CONCLUSION

In this work, we have proposed a novel and simple method for gender classification and age determination of fingerprint images based on Wavelet Transform. This method considered the frequency features of the wavelet domain. The six level Wavelet Decomposition is selected as optimum level for the gender classification by analyzing the results obtained for the database. Wavelet energy was chosen as feature vector for gender classification and Wavelet entropy was chosen as feature vector for age determination. Exact estimation of age group is achieved for the age groups 6-16, 17-49 and above 50. For the age group of 25-49 success rate is not reasonably good. Future work can be done for the classification of age group 6-16 and above 50.

REFERENCE


