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# Fingerprint Detection Applying Discrete Wavelet Transform on ROI

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**Abstract**— In this paper, a DWT based approach is proposed for verification of fingerprint in criminal investigation. The image of original fingerprint is first enhanced then thinning scheme is applied on it to select the better part of the image which is nomenclature as region of interest (ROI). Then DWT is applied on each row of the image recursively until getting a single point for each row. Finally DWT is again applied on the column vector recursively until getting a vector of four points which is used for verification of fingerprint. Similar work is done previously except the selection of ROI. The combined scheme of ROI and DWT approach of the project work provides better result of previous works.

**Index Terms**— Biometric Recognition, DWT, Image enhancement, Minutiae extraction, ROI, Thinning scheme, variance of image equivalent vector.

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## 1 Introduction

Biometric identification techniques are applied to identify an individual on the basis of an individual's characteristics (both physiological and behavioral). It is one of the most dependable and sensible approach to recognize an authorized person among several masquerades. The technology of biometric identification is applying in some specific regions to draw out furtive information such as face and eye structure, handwriting, signature, voice, hand and finger geometry, fingerprint as well as palm-print imaging [1].

The process of identifying the human fingerprint where ridge skin layout (minutiae) is used is also known as dactyloscopy. Specifically, ridge and furrow patterns on the surface/tip of the finger including bifurcations, termination and valley have been applied in a comprehensive way to determine the uniqueness of fingerprint of human being. Bifurcations are identified by the branch of one ridge, termination is the endpoint of ridge and valley is the gap between two ridges. Small and precise portions called minutiae represents those local ridge characteristics, which is also called singular points or singularities. This minutiae-based approach has minimized the tiresome job of manual classification and matching method.

Therefore, according to the methodology of Henry Classification System [2], [3], there exist three main fingerprint textures: loop, whorl and arch. Generally, Automatic Fingerprint Identification Systems (AFIS) performs three basic steps to recognize fingerprint: pre-processing, region of interest (ROI) extraction and finally classification [4], [5]. Several approaches of fingerprint matching have been proposed in recent literatures. One approach is taking the 9$^{th}$ level DWT of the original fingerprint image; where the slopes of the three linear lines are obtained and stored as matrix form and used as template value for comparing with others explained in [6]. The fingerprint images are matched based on the features extracted in the wavelet domain. Another, hierarchical fingerprint matching system is proposed in [7] that utilized features at three levels-Level 1(pattern), Level 2(minutia points) and Level 3 (pores and ridge contours), extracted from high resolution fingerprint scans. Here Gabor filters and wavelet transform are used to automatically extract the Level 3 features and are locally matched using Iterative Closest Point (ICP) algorithm. K. Thaiyalnayaki et al [8] propose a combination of features (standard deviation, kurtosis, and skewness) for multi-scale and multi-directional recognition of fingerprint, uses Canberra distance metric to determine the similarity between the texture classes. Fingerprint identification using Wavelet Transform (WT) and Probabilistic Neural Network (PNN) is proposed in [4] where the feature vector is obtained by performing one-dimensional DWT. Gabor Filter based fingerprint classification using support vector machines (SVM) is proposed in [2]. A one step method using Gabor filters for directly extracting fingerprint features from grey level images for a small scale fingerprint recognition system is introduced by C.J. Lee and S.D. Wang [9]. In [10], an identification system uses a gray level watershed method based on edge detection to find out the ridges present on a particular fingerprint image for compare. B. Tan et al [1] present a detection method based on noise analysis along the valleys in the ridge-valley structure of fingerprint images. A neural network based method is applied and trained in [11] throughout the fingerprint skeleton to locate various minutiae. Another fingerprint recognition based on wavelet domain features is presented in [12]. The features are directly extracted from the wavelet transform and the recognition performance achieved by using the proposed wavelet features were evaluated using a K-NN classifier.

In this paper we used combination of ROI, binarization of an image and DWT to extract the feature of a fingerprint. The paper is organized like: section 2 deals with theoretical approach of discrete wavelet transform (DWT) and its application in feature detection of fingerprint is shown by a flowchart with 8 steps, section 3 gives the results of the paper and finally section 4 concludes the entire analysis.


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## 2 METHODOLOGY

In this paper, we consider more than 200 fingerprints of different persons. The goal of this paper is to find out the similarity between the fingerprints of the same person and dissimilarity between different persons. The system model starts with normal preprocessing approach. The enhancement process prepares to level-up the image and makes better the ridge pattern clarity so that it can run with maximum degree of favorable termination in further processing. At first an RGB fingerprint image is taken as an input image. The RGB image is then enhanced to increase the quality of the fingerprint image. Enhancement is performed by binarizing the image to highlight the ridges in the fingerprint with black color while furrows are white. Ridge thinning scheme is then applied to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. After the operation the ridges of the image become thinner and separable. We then determine Region of Interest (ROI) of the image to eliminate the unnecessary part of the fingerprint image. The ROI of the image is then extracted from the original image. Now DWT is applied recursively on each row of the resulting image until we find a single point for each row. DWT is again applied recursively on the resulting column vector until we get only 4 points, i.e. a vector of dimension 1x4. The corresponding vector for each fingerprint image is then stored in the database.

We use one dimensional discrete wavelet transformation (DWT) on each row vector of the image in this paper. The DWT expressed as W(m, n) is a sampled version of continuous wavelet transform of W(a, b); where the parameters a and b is sampled in dyadic grid, i.e., $a = 2^m$ and $b = n2^m$. Wavelet is expressed like [13],

$$\Psi_{a,b}(t) = \Psi\left(\frac{t-b}{a}\right) = \Psi\left(\frac{t-n2^m}{2^m}\right) = \Psi(2^m t - n) = \Psi_{m,n}(t) \qquad (1)$$

; Which is the dilated and translated version of the mother wavelet.

The DWT of $f(t)$ with respect to a wavelet $\psi(t)$ is defined as,

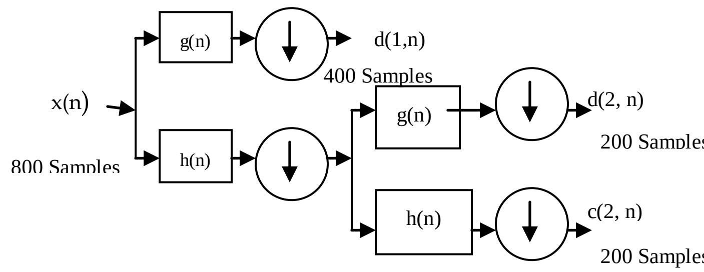
$$d(m,n) = \frac{1}{2^m}\int_{2^m n}^{2^m(n+1)} f(t)\psi(2^{-m}t - n)dt \qquad (2)$$

Here $d(m, n)$ is equivalent to continuous wavelet transform W(a, b) when $a = 2^m$ and $b = n2^m$ .

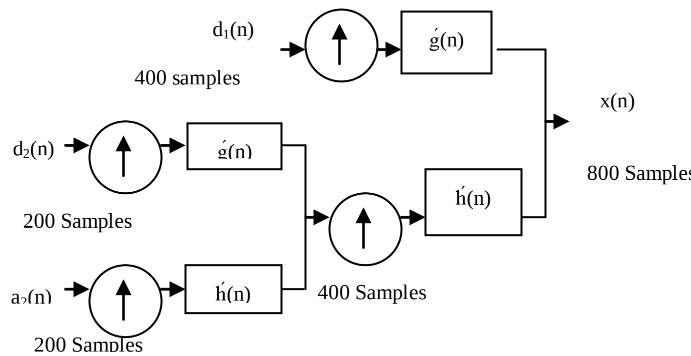
Inverse operation i.e IDWT is expressed like,

$$f(t) = \sum_{m=-\infty}^{\infty}\sum_{n=-\infty}^{\infty} d(m,n)2^{-m/2}\psi(2^{-m}t - n) \qquad (3)$$

The DWT is computed by successive lowpass and highpass filtering (also known as filter bank) of the discrete time-domain signal along with down sampling by two provides Approximation and Detail components. Two level decomposition tree of DWT can be expressed by the Fig.1(a) where the impulse response of high pass and low pass filters are g(n) and h(n) respectively. The reconstruction of original sequence $x(n)$ is the reverse process of decomposition. The approximation and detail coefficients at every level are upsampled by two then passed through the high pass and low pass synthesis filters of impulse response of $\acute{g}(n)$ and $\acute{h}(n)$ then added. This process is continued through the same number of levels as in the decomposition process to obtain the original signal. Fig.1(b) shows two levels wavelet reconstruction tree [14],[15].




(a) Decomposition tree of DWT




(b) Reconstruction tree of DWT

Fig.1 Two levels filter banks of DWT

The entire process or methodology adopted by this study is shown by the flowchart of Fig. 2.

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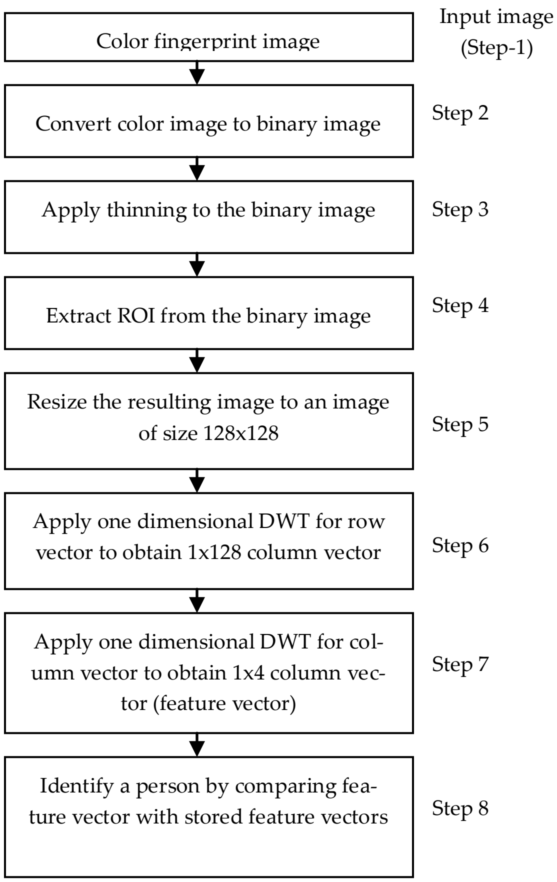



**Fig. 2** Block diagram of fingerprint detection technique

Finally the distance and slope between the 3rd and 4th points of each image equivalent vector is evaluated.

Let the coordinates of 3rd and 4th point of *i*th vector is ($x_{3i}$, $y_{3i}$) and ($x_{4i}$, $y_{4i}$) respectively. The length and slope of the connecting line:

$$l_i = \sqrt{(x_{3i} - x_{4i})^2 + (y_{3i} - y_{4i})^2} \quad ,$$

$$\tan\theta_i = \frac{y_{3i} - y_{4i}}{x_{3i} - x_{4i}} \tag{4}$$

The variance of $l_i$ and $\theta_i$ are:

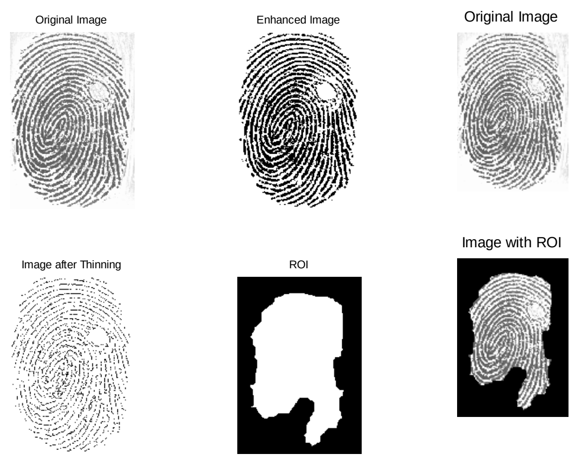
$$Var(l_i) = \frac{\sum_{i=1}^{N} (l_i - \bar{l})^2}{N}; \; \bar{l} = \frac{\sum_{i=1}^{N} l_i}{N} \tag{5}$$

$$Var(\tan\theta_i) = \frac{\sum_{i=1}^{N} \left( \tan\theta_i - \frac{\sum_{k=1}^{N} \tan\theta_k}{N} \right)^2}{N} \tag{6}$$

The slope $\tan(\theta_i)$ or distance $l_i$ of a group of images is considered as a random variable whose variance give the indication of whether all the fingerprints come from the same person or not.

## 3. Experiments And Performance Evaluation

In this section we present the results of fingerprints based on the methodology of previous section. Fig. 3(a) shows the original image, enhanced image, image after thinning and extracted ROI of person-1. Fig. 3(b) shows original image with its selected ROI. The gray scale image with selected ROI is converted to binary image then row and column wise DWT is applied on it for the result of vector of dimension 1×4. The binary image of the selected region and the plot of its corresponding vector are shown in Fig. 4.




(a) (b)

**Fig. 3** Original, enhanced and thinning image with ROI of person-1

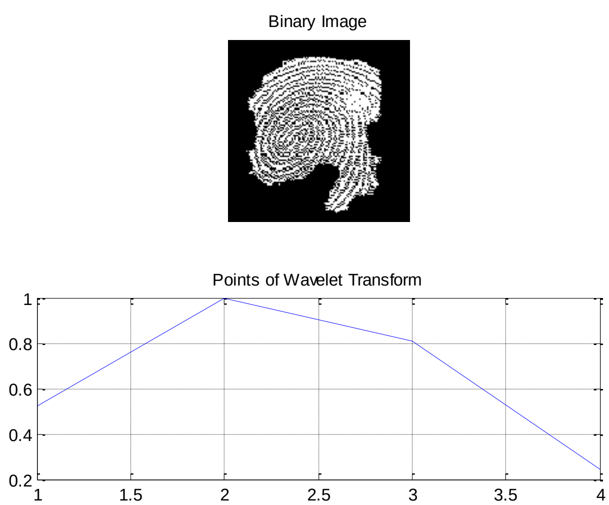



**Fig. 4.** Binary image with 4-points of wavelet transform of person-1

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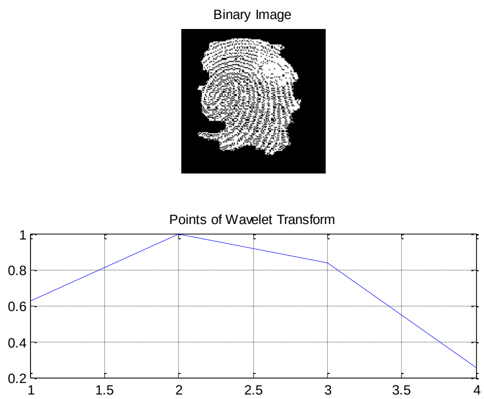
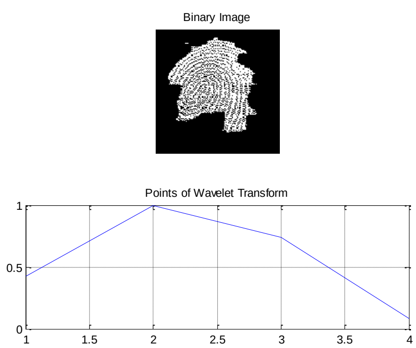
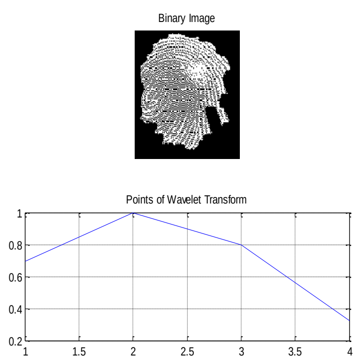
More than 200 fingerprints are collected to verify the methodology of the paper but only 10 fingerprints are shown in this section to represent the result of DWT of a binary image. The binary image of selected region and its vector is shown for three fingerprints of same person in Fig.5 to visualize the similarity of three vectors. Finally five vectors of same person are compared in Fig.6. Similar analysis is also done for fingerprint of five different fingerprints shown in Fig.7 and 8 respectively to observe the dissimilarities of vector.




(i)




(ii) (iii)

**Fig. 5** Binary image of selected region and its vector for three fingerprints of same person

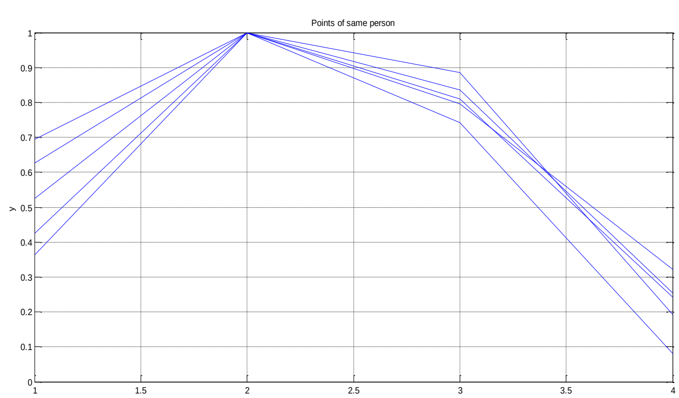
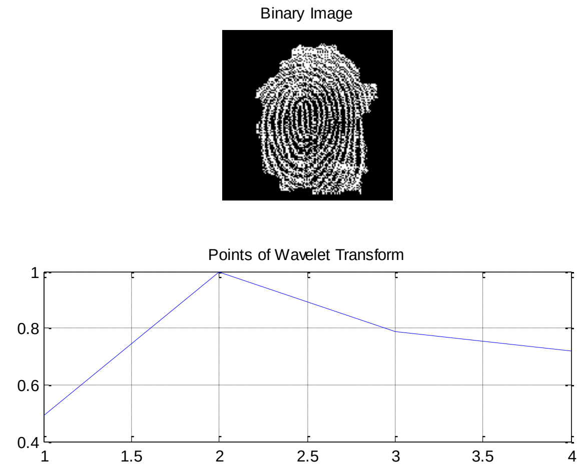
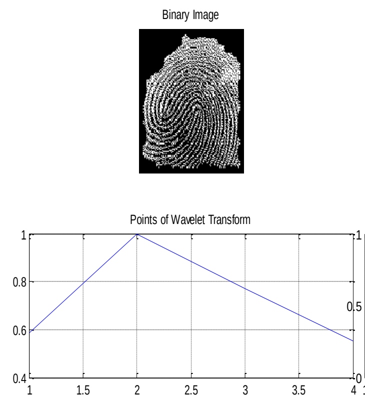
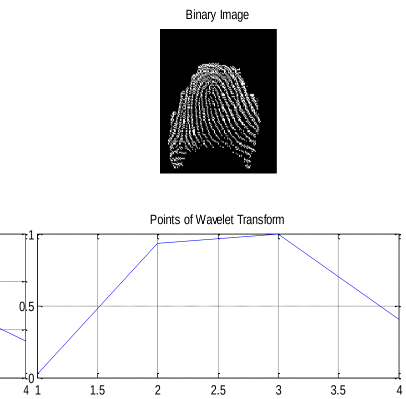



**Fig. 6** Comparison of five vectors of same person




(i) person-1




(ii) person-2 (iii) perso

**Fig. 7** Binary image of selected region and its vector for three different persons

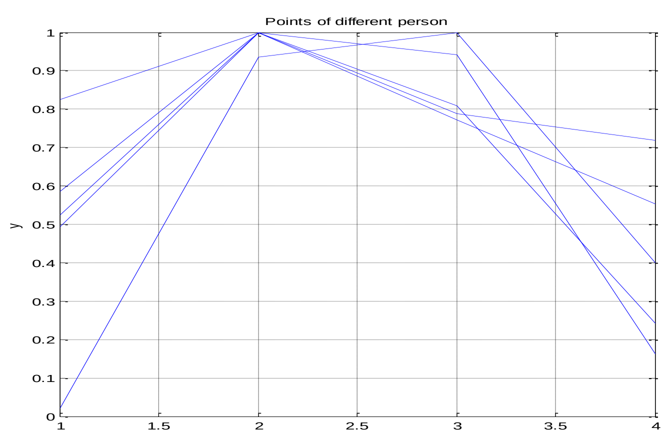



**Fig. 8** Comparison of five vectors of different person

The parameters $Var(l_i)$ and $Var(\tan\theta_i)$ of (5) and (6) are found much larger for the case of the images of different person compared to those of same person. The phenomenon is visualized from Table-1 and Table-2.

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**TABLE 1** IMAGES OF SAME PERSONS

| Images | $\tan\theta_i$ | $l_i$ | Var ( $\theta_i$ ) | Var ( $l_i$ ) |
|---|---|---|---|---|
| 1 | -0.5693 | 1.1873 | 0.0036 | 0.0016 |
| 2 | -0.4475 | 1.1092 | | |
| 3 | -0.5181 | 1.1510 | | |
| 4 | -0.5105 | 1.1461 | | |
| 5 | -0.6040 | 1.2149 | | |

**TABLE 2** IMAGES OF DIFFERENT PERSONS

| Images | $\tan\theta_i$ | $l_i$ | Var ( $\theta_i$ ) | Var ( $l_i$ ) |
|---|---|---|---|---|
| 1 | -0.2213 | 2.0500 | 0.0604 | 0.1725 |
| 2 | -0.0699 | 1.0024 | | |
| 3 | -0.5105 | 1.1461 | | |
| 4 | -0.6624 | 1.2682 | | |
| 5 | -0.5404 | 1.1662 | | |

The parameter $l_i$ and $\theta_i$ of a newly selected fingerprint is compared with the corresponding parameters of database of a person. If parameters merge closely then the newly selected fingerprint is also from that person; otherwise it will be of different person. Our proposed method shows the success rate of 94.6% which is about 1.6% better than the previous technique of DWT using the same images.

## 4 CONCLUSION

The combined scheme of ROI and DWT gives better result than the previous work of involving only DWT. The main drawback of this scheme is that the quality of input image should be free from regional blur and mingle of ink. The most professional technique in identification of fingerprint is minutiae based approach where termination and bifurcation points are considered as the minutiae of a fingerprint. This technique requires huge space to create database of since each image has to be stored on the database. On the other hand the proposed technique requires only a vector of four points to store an image in the database. The entire work can be enhanced incorporating invariant moment on the image of ROI for verification of fingerprint.

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