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RESEARCH ARTICLE

Finger Vein Recognition Using Haar Wavelet Transform

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Abstract— Finger vein is an important biometric technique for personal identification and authentication. The finger vein is a blood vassal network under the finger skin. The network pattern is distinct for each individual, unaffected by aging and it is internal. i.e. inside human skin which can always guarantee more security authentication.

finger-vein recognition systems capture images by using near infrared (NIR) illumination in conjunction with a camera. However, such systems can face operational difficulties, since the scattering of light from the skin can make capturing a clear image difficult, which represent the major challenge in our proposed system, which is how to localize the vein grid, and the following challenges are choosing the suitable feature vector to identify the vein pattern. The attracting features of the Haar Wavelet Transform, including fast for implementation and able to analyse the local feature makes it the suitable choice in our system.

The system was tested over a database collected from 106 volunteers, where 6 images are collected for each person. The attained identification result is encouraging where equal error rate for one level decomposed wavelet was (98.7%), and when increasing the levels of decomposed wavelet was (99.8%).

Keywords— Finger vein, blood vassal, Near infrared, Haar Wavelet, decomposed wavelet.

I. INTRODUCTION

Biometric human identification has become very important due to pitfalls even in extreme security systems, and alternative methods that can be used in place of or together that have been being sought during the last decade. Many biometrics authentication systems have deployed but every type of unimodal biometrics have its own demerits based on the traits, capturing device, database and feature of that traits. Finger print is a popular trait for recognition but it can be easily spoof using dummy fingerprint, sensitive to dirt, wet and age. Facial recognition is sensitive to the face expression and age. Voice recognition is also depends upon the environmental condition and not secure from the recorded voice. Considering the challenges in the current recognition system now time is come to design the robust unimodal recognition system to secure the privacy [1].

Finger vein biometric system can verify a person's identity by recognizing the pattern of blood veins in the Finger. Finger vein recognition uses the vascular patterns of an individual's Finger as personal identification data. It has been shown that finger vein pattern is distinctive enough for human biometric identification [2], Like fingerprints, the pattern of blood veins in the Finger is unique to every individual, even twins have different patterns and apart from size, this pattern will not vary over the course of a person's lifetime.

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For capturing a vascular network, hemoglobin plays an important role by absorbing infrared light, and after absorbing infrared light vein patterns are captured. Distance is very important in absorbing infrared light between skin and vessels: bigger distance leads to more noise in the captured image [3]. Finger veins biometric are robust and steady human authentication more than other biometric technologies so it is considered to be one of the most reliable biometrics for personal identification.

II. Related Work

Many algorithms were proposed and implemented to recognize finger vein, [4] discussed an approach of finger vein recognition by combining local feature based on a Local Binary Pattern (LBP) without segmenting accurate finger vein regions and global feature information of the finger veins based on Wavelet transform was extracted, the two score values by the LBP and Wavelet transform were combined by the Support Vector Machine (SVM). As experimental results, the equal error rate (EER) was 0.011%. [5] proposed a finger vein recognition system, for feature extraction they had been produce a method based on dividing vein image into blocks and for each image sub-block, wavelet moment was performed and PCA features extracted. Experimental results show that error rate FAR was 0.7%, rejection rate FRR of 1.05%. [6] proposed a real time embedded finger vein recognition system for personal authentication and vehicle security. They had use Haar classifier to extract the features for finger vein recognition algorithm. The finger vein image is matched by calculating the Euclidean distance and the error rate (ERR) was 0.06.

III. Finger Vein Recognition System

The system layout is demonstrated in the Fig.1. There are four stages in finger vein recognition system. These are analogues in most biometric techniques: (1) Capture of the finger vein image pattern, (2) Pre-Processing of the image, (3) Feature pattern extraction from the image, (4) Pattern matching and outcome decision.

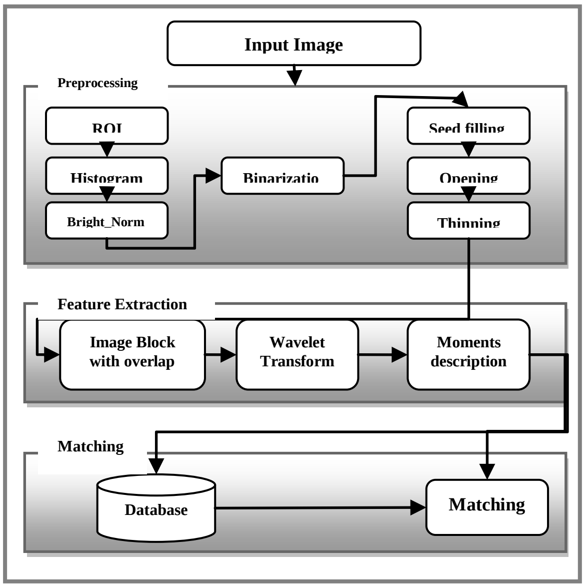

Fig. 1 The Proposed System Layout

1. Preprocessing

1.1 ROI

The original image is captured with undesired backgrounds, which reduce the accuracy of matching stage and increase the complexity of the system. We employ sobel edge detection operator to segment the finger image from the background by highlighting the edges of the finger. There are two major horizontal lines detected represented the finger edge. The cropping points are selected after satisfying two conditions: (i) the pair of the edge points is the widest pair among all pairs. (ii) The range of the pair of the edge points is between (55%) and (65%) of the original image height. Finally, the image is cropped horizontally at the cropping points.

1.2 Image Enhancement

Vein patterns images are acquired using the infrared (IR) cameras. The acquired images are low contrast and blurred in nature, therefore Contrast enhancement techniques are required to expand the range of brightness values in an image so that the image can be efficiently displayed in a manner desired by the analyst as is shown in Fig. 2. The density values in a scene are literally pulled farther apart, that is, expanded over a greater range. The effect is to increase the visual contrast between two areas of different uniform densities. This enables the analyst to discriminate easily between areas initially having a small difference in density.

A. Histogram Equalization

The veins image patterns are enhanced using the histogram equalization, in this technique; histogram of the original image is redistributed to produce a uniform population density [7]. This is obtained by grouping certain adjacent grey values. In order to enhance the vein patterns from the back ground, the number of grey levels in the enhanced image is less than the number of grey levels in the original image. If the histogram of any image has many peaks and valleys, it will still have peaks and valley after equalization, but peaks and valley will be shifted. Because of this, "spreading" is a better term than "flattening" to describe histogram equalization. In histogram equalization, each pixel is assigned a new intensity value based on its previous intensity level. *L* is the number of possible intensity values, often 256. Let *p* denote the normalized histogram of *f* with a bin each possible intensity. So

$$pn = \frac{number\ of\ pixels\ with\ intensity\ n}{total\ number\ of\ pixels} \qquad ....1$$

$n = 1,2, \dots , L - 1.$

The histogram equalized image g will be defined by:

$$g_{i,j} = floor\ ((L-1)\sum_{n=0}^{f\ i,j} pn) \qquad .... 2$$

Where floor () rounds down to the nearest integer.

B. Brightness Normalization

As the finger vein image effected by the light source the resulted images may have different contrast for each class, which may affect the following feature extraction and matching stage. Therefore we need to enhance and to uniform the contrast of the vein image to bring it into an intensity range that is more normal or suitable for features extraction phase. First we have to calculate the mean (M) and the standard deviation (δ) of the finger vein image, then we applied the contrast stretching as in the following equation:

$$G^{'(x,y)} = \frac{A}{\delta}(G(x,y) - M) + 128 \qquad ....3$$

Where G(x, y) is the pixel intensity and G'(x, y) is the pixel intensity in the new stretch range. The suitable value of A is assigned by testing.

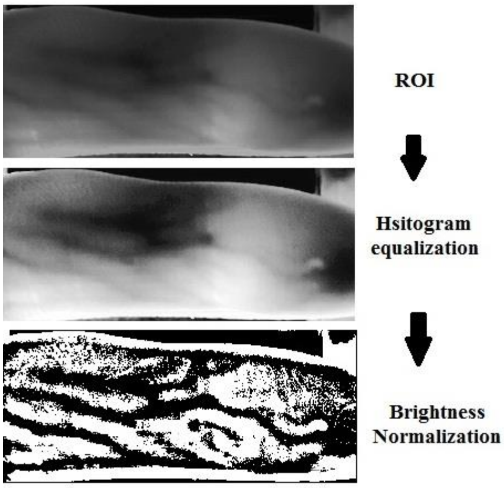

Fig. 2 Image Enhancement

1.3 Image Segmentation

A. Binarization

The simplest method of image segmentation is called the threshold method. This method is based on a threshold value to produce a binary image from a grey-scale image. The key of this method is to select the threshold value. Global threshold is suitable to use for binarizing the enhanced image using the following criterion

$$g(x,y) = \begin{cases} 255 & if\ f(x,y) > T \\ 0 & if\ f(x,y) \leq T \end{cases} \qquad \text{...4}$$

The value of T is assigned by testing.

B. Morphological Operation

We will need to eliminate the noise that would be appear after the segmentation process to allocate the shape of the vein since it affect the form, structure or shape of an object. The concept is quite simple. Conceptually, a small odd-sized mask, typically 3×3 , is scanned over a binary image. If the binary-valued pattern of the mask matches the state of the pixels under the mask (hit), an output pixel in spatial correspondence to the center pixel of the mask is set to some desired binary state. For a pattern mismatch (miss), the output pixel is set to the opposite binary state [8].

- Opening: opening is effective choice we use it to remove small objects from the binarized image without altering the overall shape and size of the large objects (veins object).
- Seed filling: The goal of the seed filling operations is to find the seed point and fill the object contours starting from that seed point [9], if the image contains a patch of noise, these patches would not be effected by the opening operation so, the seed fill algorithm remove like this patch through checks the value of the mask's pixels to the right, left, down and up of the current pixel then connecting these pixels, A working memory is needed to keep the record of all seed filling points.

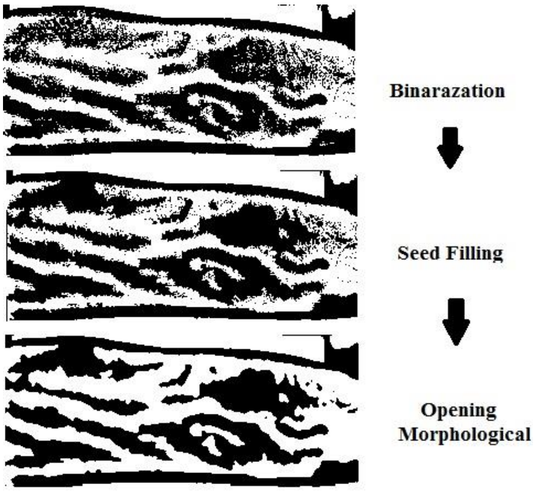

Fig. 3 Image Segmentation

1.4 Thinning

Thinning is one types of morphological function it is used to remove selected foreground pixels from a binary image. This function used to join up the output of edge detector by shrink all lines to a five pixel thickness for better performance, than single pixel which lead to losing some important information [10]. This process has accuracy for matching function as is shown in Fig. 4.

Fig. 4 Thinned Image

2. Feature Extraction using Haar Wavelet Transform Moments

The attracting features of the Haar wavelet transform, including fast implementation and able to analyze the local feature by determining the location of low frequency area and high frequency area, Considering that the Haar functions are the simplest wavelets [11] for signal and image compression and feature extraction. Wavelet moment is an invariant descriptor for image features. A wavelet moment feature is invariant to image rotation, translation and scaling so it is successfully applied in the pattern recognition [5], and is applied as in the following steps:

Step1: divide the vein image into blocks with overlaping to overcome the variation in the image captured for the same person due to positioning during the image capture process. The value of overlapping length is taken as a ratio of block length. The block length is obtained by dividing the image length by the number of blocks as is shown in Fig. 5. The effects of both the number of blocks and overlapping ratio values is tested to find their suitable values, which lead to best recognition rate as is shown in Table 1. Notice that the width and height of the image are not equal, so the block dimensions.

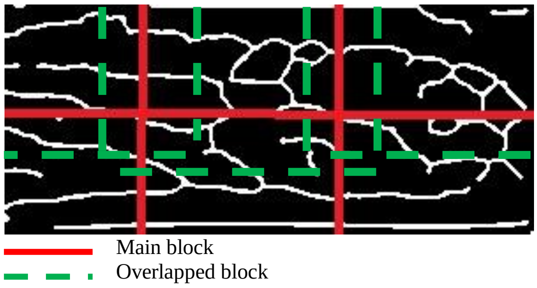

Fig. 5 Image Partitioning

Step2: for each divided block apply 2-D wavelet transform, which decompose it into four sub-images, as is indicated in Fig. 6, where LL represents an approximate low frequency vectors, HL represents high frequency vectors in horizontal direction, LH represents high frequency vectors in vertical direction, HH represents diagonal high frequency vectors. After first decomposition, LL quarter, i.e., the approximate sub band, is submitted for next decomposition, as Fig. 7 indicates, and then the LL quarter from the second decomposition is submitted for next decomposition as Fig. 8 indicates.

Fig. 6 1_Level Wavelet Decomposition

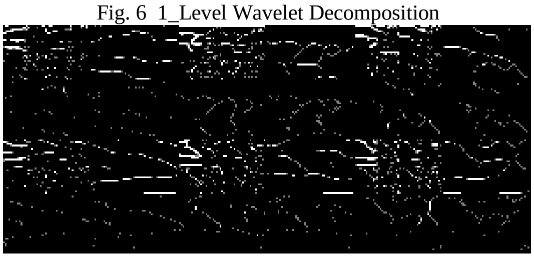

Fig. 7 2_Level Wavelet Decomposition

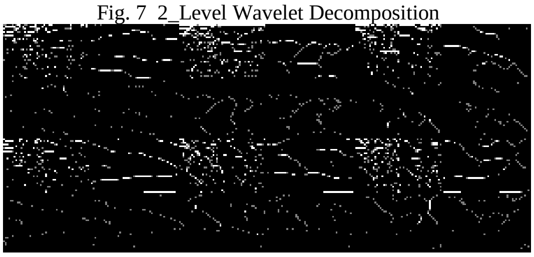

Fig. 8 3_Level Wavelet Decomposition

Step3: for each sub band belongs to the block image, the energy of wavelet is computed by using the following equation:

$$\sum_{x=xs}^{xe-1} \sum_{y=ys}^{ye-1} wavelet(i,j)^2 \quad \text{..........}5$$

Where (*x*s, ys) are the range of coordinates of the tested block image, wavelet (*i*, *j*) is the wavelet sub bands.

3. Matching

This stage calculates the degree of matching between two vein patterns. The extracted vein patterns of the input image can directly be compared with the stored templates, which represent the mean value of the trained samples belong to a certain class. A similarity measure would be used to evaluate the similarity degree between a template and an input pattern. In this work the Euclidean similarity measures, i.e., mean square difference, was used.

IV. Experiment Results

The database in this research is carried out from SDUMLA-HMT finger-vein database that is publicly available [12]. Every image is a grayscale that is stored in "bmp" format with 320×240 pixels in size. In this work the images of index finger which was supplied to the designed system, were taken from 106 volunteers, 6 sample for each, the total number of the database where 636 image. The experimental results show that the partitioning into blocking with overlap has improved the recognition accuracy and helps to overcome on the partial loss in low-quality finger vein image. This is shown in Table 1.

TABLE 1 The Recognition Rate of using Different Wavelet Passes with Different Block Size and Overlap Ratio

Wavelet Level	*Block Size*	*Overlap Ratio*	*Recognitio n Rate*
1	*10 x 6*	*0.9*	*92.9%*
2	*10 x 6*	*0.9*	*99.2%*
3	*10 x 6*	*0.9*	*99.3%*
1	*12 x 8*	*0.9*	*96.3%*
2	*12 x 8*	*0.9*	*99.8%*
3	*12 x 8*	*0.9*	*99.8%*
1	*14 x 10*	*0.9*	*97.4%*
2	*14 x 10*	*0.9*	*99.8%*
3	*14 x 10*	*0.9*	*99.8%*
1	*16 x 12*	*0.9*	*98.7%*
2	*16 x 12*	*0.9*	*99.6%*
3	*16 x 12*	*0.9*	*99.8%*
3	*14 x 12*	*0.5*	*99.5%*
3	*14 x 12*	*0.7*	*99.6%*

V. Conclusions

In this research, a finger vein recognition model including preprocessing, feature extraction, partitioning, Haar wavelet transform, and matching. At the feature extraction stage first or second or third-level Haar wavelet decomposition features are used and tested. The experimental result shows that although the first-level Haar wavelet decomposition features have given good recognition rate (97.4%), and in multi-level Haar wavelet decomposition features have increase recognition rate to (99.8%). The experimental results show that the partitioning into blocking with overlap has improved the recognition accuracy and helps to overcome on the partial loss in low-quality finger vein image. The recognition rate is high affected by variation of block length and overlapping ratio.

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